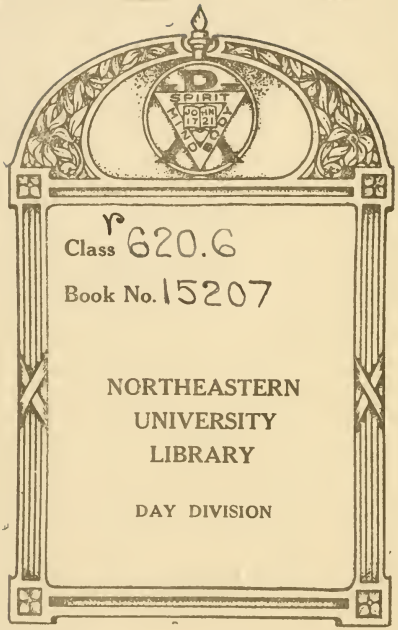


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CONTENTS AND INDEX

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CONTENTS.

VOLUME VIII, 1921.

For alphabetical index, see page v.

No. 1. JANUARY.

PAGE

Water-Power Development in New England. *H. K. Barrows* 1
The St. Lawrence River Project. *Henry I. Harriman* 43
Memoir of Deceased Member:
Loammi Franklin Baldwin 50

No. 2. FEBRUARY.

Rat Extermination and Proofing with Relation to the Prevention of Plague. *L. L. Williams* 53
Discussion by *H. C. Mosman, Dana Somes, H. P. Eddy* and *Dr. Williams* 63
Memoir of Deceased Member:
William M. Brown 68

No. 3. MARCH.

The New Methods of Proportioning Concrete in Theory and Practice. *Roderick B. Young* 73
Discussion by *L. N. Edwards* 106
Several Years' Experiments on the Disposal of Worcester Sewage. *Roy S. Lanphear* 109

No. 4. APRIL.

Address at the Annual Meeting. *F. A. Barbour* 123
The Responsibility of Organized Labor for the Stagnation in the Building Industry. *Charles R. Gow* 129

No. 5. MAY.

Construction Costs. *W. N. Connor* 157
Discussion by *Leonard C. Wason* 195
Memoir of Deceased Member:
Louis Bertrand Vaughan 198

15207

No. 6. JUNE.

PAGE

The Public Works of Modern Greece. *Walter E. Spear* 203
Memoirs of Deceased Members:
James C. Scorgie 225
David Herbert Andrews 227

No. 7. SEPTEMBER.

Inverted Siphons for Sewers. Final Report of Committee 231
Memoir of Deceased Member:
Edmund Mortimer Blake 287

No. 8. OCTOBER

Papers in Memory of Samuel Everett Tinkham
Samuel Everett Tinkham. *Edward W. Howe* 291
S. E. Tinkham's Connection with the Boston Society of Civil Engineers as Its Secretary for Thirty-Seven Years. *Desmond FitzGerald* 294
Samuel Everett Tinkham: His Services as an Engineer. *Frederic H. Fay* 297
A Brother Mason's Tribute. *H. K. Berry* 306

No. 9. NOVEMBER.

Federal Water-Power Legislation. *George C. Danforth* 311

No. 10. DECEMBER.

Labor Problems of To-day. *E. A. Johnson* and *James Gauld* 325
Discussion by *William Stanley Parker, Morton C. Tuttle* and *Charles R. Gow* 336
Memoir of Deceased Member:
Roy C. Aiken 352

INDEX.

VOLUME VIII, 1921.

Abbreviations. — D. — Discussion; I. — Illustrated.
Names of authors are printed in *italics*.

PAGE

Address at the Annual Meeting. *Frank A. Barbour* ..... April, 123
Aiken, Roy C., Memoir of ..... Dec., 352
Andrews, David Herbert, Memoir of ..... June, 227
Annual Meeting, Address at the. *Frank A. Barbour* ..... April, 123

Baldwin, Loammi Franklin, Memoir of ..... Jan., 50
Barbour, Frank A. Address at the Annual Meeting ..... April, 123
Barrows, H. K. Water-Power Development in New England . . I., Jan., 1
Berry, J. K. A Brother Mason's Tribute (to S. E. Tinkham) . . . Oct., 306
Blake, Edmund Mortimer, Memoir of ..... Sept., 287
Brother Mason's Tribute (to S. E. Tinkham). *J. K. Berry* ..... Oct., 306
Brown, William M., Memoir of ..... Feb., 68
Building Industry, The Responsibility of Organized Labor for the Stagnation in the. *Charles R. Gow* ..... April, 129

Concrete, The New Methods of Proportioning, in Theory and Practice. *Roderick B. Young* ..... I., Mar., 73; D., Mar., 106
Connor, W. N. Construction Costs ..... I., May, 157
Construction Costs. *W. N. Connor* ..... I., May, 157; D., May, 195
Costs. See Construction.

Danforth, George C. Federal Water-Power Legislation ..... Nov., 311
Deceased Members. See Memoirs of.
Disposal of Worcester Sewage, Several Years' Experiments on. *Roy S. Lanphear* ..... Mar., 109

Eddy, H. P. Discussion of Rat Extermination ..... Feb., 65
Edwards, L. N. Discussion of New Methods of Proportioning Concrete ..... March, 106

PAGE

Fay, *Frederic H.* Samuel Everett Tinkham: His Services as an Engineer ..... Oct., 297
Federal Water-Power Legislation. *George C. Danforth* ..... Nov., 311
FitzGerald, Desmond. Paper in Memory of S. E. Tinkham ..... Oct., 294

Gauld, *James.* Labor Problems of To-day ..... Dec., 332
Gow, Charles R. The Responsibility of Organized Labor for the Stagnation in the Building Industry ..... April, 129
Discussion of Labor Problems of To-day ..... Dec., 345
Greece, The Public Works of Modern. *Walter E. Spear* ..... I., June, 203

Harriman, *Henry I.* The St. Lawrence River Project ..... Jan., 43
Howe, Edward W. Paper in Memory of S. E. Tinkham ..... Oct., 291

Inverted Siphons for Sewers. Final Report of Committee ..... I., Sept., 231

Johnson, *E. A.* Labor Problems of To-day ..... Dec., 325; D., Dec., 351

Labor. See Organized.
Labor Problems of To-day, *E. A. Johnson* and *James Gauld*, Dec., 325; D., Dec., 336
Lanphear, Roy S. Several Years' Experiments on the Disposal of Worcester Sewage ..... March, 109
Legislation, Federal Water Power. *George C. Danforth* ..... Nov., 311

Members, Deceased. See Memoirs of.
Memoirs of Deceased Members:
Roy C. Aiken ..... Dec., 352
David Herbert Andrews ..... June., 227
Loammi Franklin Baldwin ..... Jan., 50
William M. Brown ..... Feb., 68
Edmund Mortimer Blake ..... Sept., 287
James C. Scorgie ..... June, 225
Louis Bertrand Vaughan ..... May, 198
Methods of Proportioning Concrete in Theory and Practice, The New. *Roderick B. Young* ..... I., Mar., 73; D., Mar., 106
Mosman, H. C. Discussion of Rat Extermination ..... Feb., 63

New England, Water Power Development in. *H. K. Barrows* ..... I., Jan., 1
New Methods of Proportioning Concrete in Theory and Practice. *Roderick B. Young* ..... I., Mar., 73; D., Mar., 106

PAGE

Organized Labor, Responsibility of, for the Stagnation in the Building Industry. *Charles R. Gow*.....April, 129

Parker, William Stanley. Discussion of Labor Problems of To-day.....Dec., 336
Plague, Rat Extermination and Proofing with Relation to the Prevention of. *L. L. Williams*.....Feb., 53; D., Feb., 63
Public Works of Modern Greece, The. *Walter E. Spear*.....I., June, 203

Rat Extermination and Proofing with Relation to the Prevention of Plague. *L. L. Williams*.....Feb., 53; D., Feb., 63
Responsibility of Organized Labor for the Stagnation in the Building Industry. *Charles R. Gow*.....April, 129

Samuel Everett Tinkham's Connection with the B. S. C. E., as Its Secretary for Thirty-seven Years. *Desmond FitzGerald*.....Oct., 294
Samuel Everett Tinkham: His Services as an Engineer. *Frederic H. Fay*.....Oct., 297
Scorgie, James C., Memoir of.....June, 225
Several Years' Experiments on the Disposal of Worcester Sewage. *Roy S. Lanphear*.....Mar., 109
Sewage, Several Years' Experiments on the Disposal of Worcester. *Roy S. Lanphear*.....Mar., 109
Sewers, Inverted Siphons for. Final Report of the Committee...Sept., 231
Siphons. See Inverted.
Somes, Dana. Discussion of Rat Extermination.....Feb., 63
Spear, Walter E. The Public Works of Modern Greece.....I., June, 203
St. Lawrence River Project, The. *Henry I. Harriman*.....Jan., 43

Tinkham, Samuel Everett, Papers in Memory of.....Oct., 291
Tuttle, Morton C. Discussion of Labor Problems of To-day.....Dec., 340

Wason, Leonard C. Discussion of Construction Costs.....May, 195
Water-Power Development in New England. *H. K. Barrows*..I., Jan., 1
Water-Power Legislation, Federal. *George C. Danforth*.....Nov., 311
Williams, L. L. Rat Extermination and Proofing with Relation to the Prevention of Plague.....Feb., 53; D., Feb., 64
Worcester Sewage, Several Years' Experiments on the Disposal of. *Roy S. Lanphear*.....Mar., 109

Young, Roderick B. The New Methods of Proportioning Concrete in Theory and Practice.....I., Mar., 73

Vol. VIII JANUARY, 1921 No. 1

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PAPERS AND DISCUSSIONS

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WATER-POWER DEVELOPMENT IN NEW ENGLAND.

By H. K. Barrows,* Member Boston Society of Civil Engineers.

(Presented December 17, 1920.)

Scope of Paper.

At the present time the total use of power in the United States for manufacturing and in power stations is over 40 million h.p., of which about 8 million h.p., or approximately 1/5, is water power. Over a million horse power of this water power is developed here in New England — in fact, considered as a unit (which would be fair in respect to area), New England leads in the amount of developed water power, the states of New York and California following in the order named.

While the larger amount of undeveloped water power is in the West — roughly, 70 per cent. of the *developed* power being east of the Mississippi River and 70 per cent. of the undeveloped power *west* of the Mississippi — there is still much opportunity for water-power development here in New England, as well as the improvement and fuller development of power sites not wholly or efficiently utilized.

It is the general purpose of this paper to review the present situation in regard to the amount and distribution of water power in New England, both developed and undeveloped, the basis for its development and use, its relative economy and the

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possibilities of improvement in the way of storage projects and redevelopment, as well as to outline some of the difficulties which at present discourage comprehensive action.

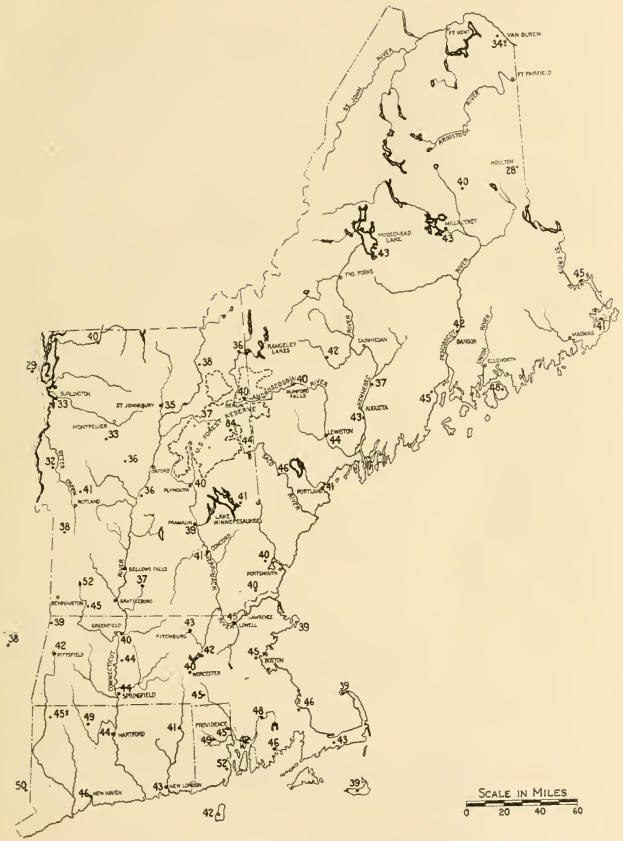
Elements Affecting the Value of the Potential Water Power of New England.

Reduced to its basic elements, potential water power depends upon the stream flow or quantity of water available and the head or fall through which the water may be utilized, — both of these elements depending fundamentally upon natural conditions. A discussion of these elements with particular reference to New England is therefore pertinent to show the basis for the important position held by water-power development in these states.

precipitation.

Amount and Variation. — The amount and distribution of precipitation is of course of fundamental importance in affecting the flow of streams. By reference to Fig. 1 it will be noted that the mean annual precipitation varies from about 32 ins. in western Vermont to a maximum amount of about 84 ins. at the summit of Mount Washington, the average for New England being probably between 40 ins. and 45 ins. A study of this map indicates that, in general, along the coast for a short distance inland the precipitation is greater than further inland or a short distance seaward. Still higher amounts are found in the elevations of the White and Green Mountains and the Berkshires, while beyond these ranges in western and northern Vermont and northern New Hampshire and Maine the least amounts occur.

Effect of Altitude. — The effect of altitude upon precipitation is marked in the Connecticut and Merrimack River basins on the *coastal* side of the White and Green Mountains, as will be noted on Fig. 2, where a plot of altitude — precipitation shows an approximate relation $P = 35 + 7.5A$, where P = mean annual precipitation in inches and A = altitude in thousands of feet. This plot also shows the lack of precipitation data for elevations over



[FIG. 1. — NEW ENGLAND ANNUAL PRECIPITATION IN INCHES.

1 000 ft.,— an unfortunate gap in our basic information upon precipitation, only imperfectly bridged over by such studies as Fig. 2, which can safely be applied only in limited areas.

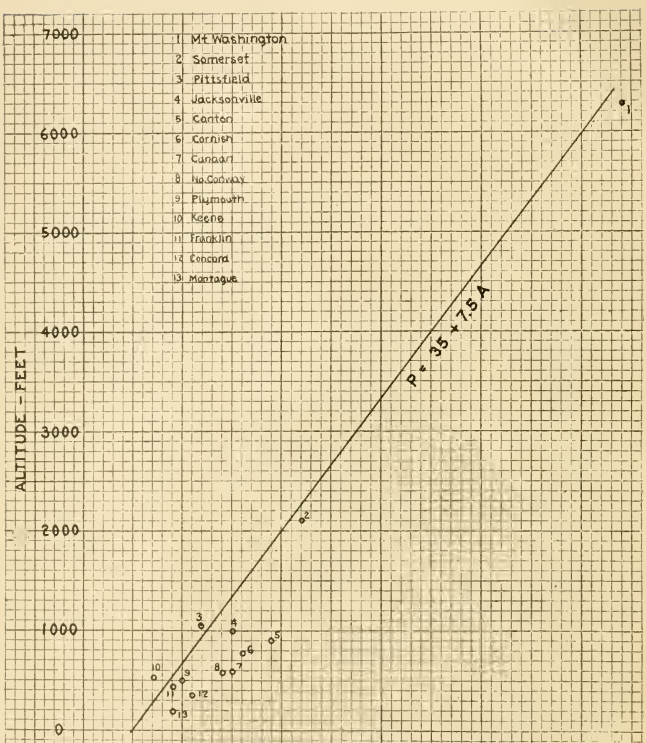


FIG. 2. — EFFECT OF ALTITUDE ON PRECIPITATION.

Variation of Mean. — The precipitation data on Fig. 1 are from records of various lengths, most of which are, however, for a sufficient length of time to give a fair determination of the mean. On Fig. 3 is shown for a number of the longer records the

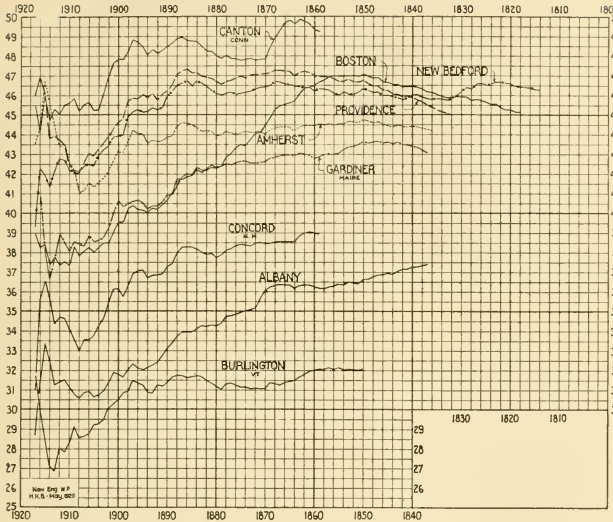


FIG. 3. — PRECIPITATION IN NEW ENGLAND. VARIATION IN YEARLY ME

variation in the yearly mean from 1917 backwards. In general, a deficiency in precipitation as regards the long-time mean has occurred during the last twenty to thirty years, as will be noted by the following:

Station.	Year of Equal Progressive Mean and Long-time Mean.
Boston	1869
New Bedford	1889
Providence	1899
Amherst	1897
Gardiner (Me.)	1863
Concord (N. H.)	1862
Albany	1837
Burlington (Vt.)	1860 ±

The Boston record shows a deficiency since about 1869, while the deficiency at Amherst reaches back only to 1897, the

latter record showing much less variation than that of Boston. New Bedford and Providence are fairly consistent with Amherst, while Albany and Burlington show in general a progressively declining precipitation since the beginning of the records.

As most of the records of stream flow in New England are not available before 1900 — and many not even then — it is evident from Fig. 3 that they represent in general a period below the average in precipitation and therefore in all probability also in run-off of streams.

Variation during Year. — Precipitation in New England is in general fairly evenly distributed through the year, as will be

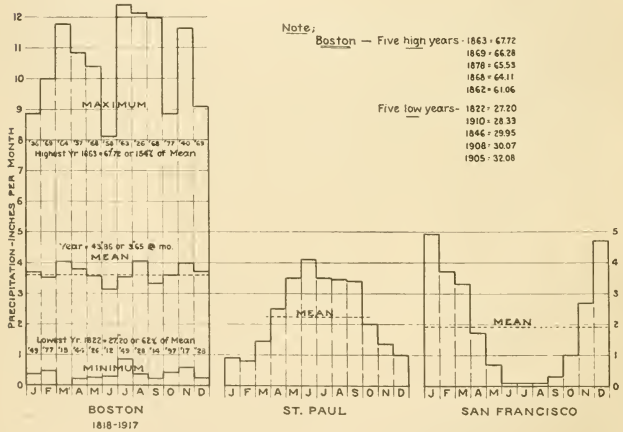


Fig. 4. — Variation in Monthly Precipitation.

noted by reference to Fig. 4, where is shown the mean, minimum and maximum precipitation at Boston by months of the year. The mean monthly precipitation is 3.65 ins., varying from 3.11 ins. (or 15 per cent. from the mean) in June to 4.04 ins. (or 10 per cent.) in both March and August.

Fig. 4 also shows for comparison the monthly mean precipitation at St. Paul and San Francisco, both of which show great variations in precipitation during the year, as well as a much less average amount than Boston.

Single months will show great variations in precipitation. Thus in March, 1915, there was no measurable amount (see Fig. 4), and minima of 0.2 in. to 0.5 in. have been reached by all months but July. A maximum of 12.38 ins. was recorded in July, 1863, and many other months have shown maxima over 10 ins. It is also noteworthy that no maximum has occurred subsequent to 1877, while minima for four months of the year have occurred since 1911.

RUN-OFF OR STREAM FLOW.

General Tendencies. — The water flowing in the rivers and streams is chiefly the residual of precipitation and the water losses due (1) to soil evaporation, (2) interception by vegetation and growing crops and (3) transpiration or water requirements of vegetation and crops. Seasonal variation also occurs in the ground-water level, this " ground storage " in a dry season furnishing much of the minimum flow of the stream. Snow storage also modifies and retards run-off, tending to concentrate it in spring floods or thaws.

As a result of these various tendencies, a stream like the Nashua River, with an average yearly precipitation of about 45 ins., will afford in the six months December to May, inclusive, about 16.7 ins., or 75 per cent. of the average total yearly run-off of about 22 ins.

During each of these six-month periods the precipitation is practically the same, viz., 22.5 ins., and hence the proportion of precipitation appearing in the stream is about 75 per cent. during the winter six months and only about 25 per cent. during the summer six months. The distribution of run-off during the season is thus much more irregular than that of precipitation.

The average yearly land water losses or retention for a given river basin do not vary as greatly as either precipitation or run-off, tending in general to increase somewhat with the amount of

precipitation. Thus, for the Nashua River rough annual values would be:

Precipitation. Inches.	Water Losses. Inches.	Run-off. Inches.
50	24	26
45	22.5	22.5
40	21	19

Individual years will of course show considerable variations, due chiefly to differences in distribution of the precipitation; individual months still greater variations; the above is simply to illustrate tendencies.

Evaporation from water surface is usually much greater than the land water losses, varying from about 40 ins. in southern New England to 25 ins. per year in the northern and more elevated regions, as shown by such measurements as are available. The introduction into a drainage area of a large reservoir for storage purposes tends therefore to reduce the total or average yield of the basin.

Precipitation can be observed without difficulty, but the land water losses or retention cannot be comprehensively measured. Hence, to determine with the necessary accuracy the water available for power developments, stream flow must be measured by days and months over as long a period as possible.

Essentials of Stream Flow Required for Water-Power Developments. — To properly lay out a water-power development the following stream flow data are needed:

(1) Low-water flow as a basis for the amount of primary or dependable power and (often) size of steam auxiliary.

(2) Daily flow over a period of years, as a basis for plant capacity and estimated output.

To permit of the study of storage projects the records should cover a dry period of years.

(3) Flood flow, to enable a safe installation with adequate spillway or gate relief.

Available Records of Stream Flow in New England. — Aside from a few excellent records of stream flow maintained by state and municipal authorities and private companies, data of stream

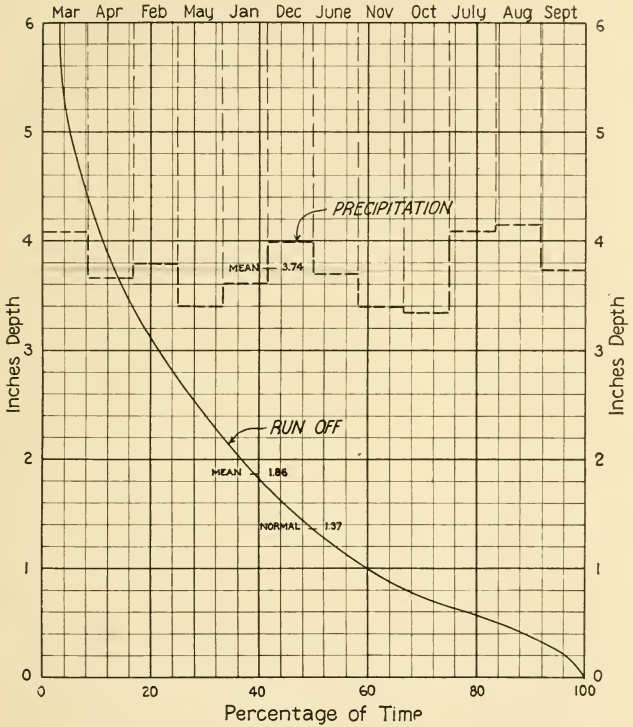


FIG. 5. — NASHUA RIVER AT WACHUSETT RESERVOIR, PRECIPITATION AND RUN-OFF, 1897–1919.

flow are now being obtained almost wholly by the Water Resources Branch of the U. S. Geological Survey, under a small federal appropriation, supplemented in several cases by state funds. For many years Congress appropriated only $150 000 annually for such work, covering the whole United States, and even now this amount is only $175 000, — an absurdly small appropriation for such important work.

The available stream-flow records extend back to 1900 only in a few cases, and the majority cover perhaps five to ten years. At present, some *53* river stations are being maintained in New England, of which *22* are in the state of Maine. It is of great importance to the further development of water power that this river-gaging work be continued without interruption, and if possible with a wider scope.

Relative Yield of New England Streams. — To ascertain the flow available and its variation during the year, for use in water-power studies, flow-duration curves are prepared, in which for the period of time covered by the records the various amounts available by months (or sometimes weeks and days) are arranged in order of magnitude for the entire period, independent of calendar order. This curve shows the flow available for any given percentage of time and serves as a basis for the determination of the proper amount of wheel capacity and average power output.

On Fig. 5 is such a curve for the Nashua River, on the basis of monthly yield for the period 1897–1919, inclusive. The *mean* run-off of 1.86 ins. per month is available (or exceeded) about 39 per cent. of the time, while for a small per cent. of time the run-off is practically zero, due to the considerable water area, about 7 per cent. (and therefore evaporation), of the Wachusett Reservoir. It is also to be noted that the normal (or 50 per cent. value) is 1.37 ins. per month, — an amount perhaps more logically representing the power value of the natural stream or of rivers where storage possibilities are limited. On Fig. 5 is also shown the order of months of the year in amount of run-off, and the average precipitation for each month. As previously noted, for Boston there is no great difference in average precipitation by months, but run-off shows a much greater variation.

On Fig. 6 are shown flow-duration curves for some typical New England streams, varying from the comparatively high average yield of the Deerfield River to the low yields of Otter Creek and of the Merrimack at Lawrence. These are based upon monthly flow except in the case of the Merrimack, which is by weeks. In the case of the Deerfield and Nashua rivers,

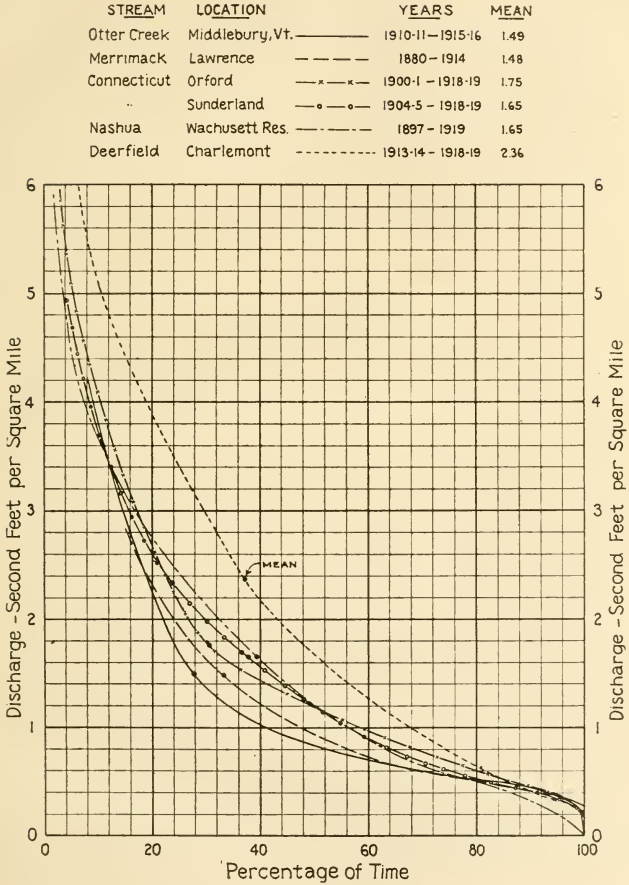


FIG. 6. — FLOW DURATION CURVES FOR TYPICAL NEW ENGLAND STREAMS.

correction for stored water held or released has been made, so that all these curves represent approximately natural run-off, although, particularly in the case of the Nashua River, the yield during the drier months of the year is considerably lowered by evaporation from water surface. While owing to lack of data these curves are for different periods of years, they give a good idea of variations to be expected in different parts of New England and show clearly the need of obtaining stream-flow data as directly applicable as possible to a given water-power project, in order to avoid serious discrepancies in power estimates.

NATURAL CONDITIONS AFFECTING WATER-POWER DEVELOPMENTS IN NEW ENGLAND.

The water-power resources of an area are largely dependent upon its geology, and the many opportunities for water-power and storage development in New England at reasonable cost are due fundamentally to favorable geological conditions. Thus, with the Kennebec and other important power streams in Maine glacial occupation of the drainage basin is largely responsible for the various water-power sites, defined by ledge outcrop (which in the typical case affords a concentrated fall succeeding a quiet stretch of river, thus affording a good "mill pond"), and also for the many natural lakes and storage basins which aid in making more constant flows of the streams.

The total area of New England is about 66 000 sq. miles, of which one half comprises the state of Maine. As a unit, New England has a little less area than Washington state (69 000 sq. miles) and a little over one third of that of California (158 000 sq. miles). Its limited area is offset as regards potential water power by the large amount of fall of its streams and consequent head available for development. In the following table are given data of fall and drainage area for a few important power streams, illustrating this feature.

River.	Distance in Miles from Mouth of River to Reach Various Elevations and Corresponding D. A. Sq. Miles.					
	500 Ft.		1 000 Ft.		1 500 Ft.	
	Dist. Miles.	D.A. Sq. Miles.	Dist. Miles.	D.A. Sq. Miles.	Dist. Miles.	D.A. Sq. Miles.
Connecticut	270	2 000	345	350	365	90
Deerfield	30	370	45	222	60	45 ±
Kennebec	90	2 500	120	1 250	...	...
Penobscot	103	1 600	140 ±	800 ±	...	...
Androscoggin	83	2 090	135	1 350	...	...

To summarize, natural conditions are favorable for water-power development in New England, with many good dam and reservoir sites, relatively high river slopes and in general a well distributed rainfall averaging from 30 ins. to 50 ins. per year.

Flow Basis used in Water-Power Developments.

The extent to which the flow of a stream can be utilized is a question of economy, in its broad aspect depending upon the relation of cost of development and value of the power developed, both of which are affected, in the case of power plants, by the extent to which the power demand varies — or, in other words, the load factor. Ideally, the limit in cost of plant will be reached when the increment in plant cost just equals the value of the increment of power gained. Practically, the problem is often indefinite owing to the uncertainty of costs or of power value, and the extent of power development must be a matter of judgment and experience. It must also be kept in mind, in comparing installations, that actual wheel capacity will also depend upon load factor and allowance for spare units. Furthermore, where power is used chiefly during the working day, as in cotton and woolen manufacture, and good pondage is available, a high wheel capacity is required to utilize the twenty-four hour flow in perhaps one third of that time.

To indicate the actual range in capacity of existing developments in New England, Table 1 has been prepared, covering some

TABLE 1.

INSTALLED WHEEL CAPACITIES AT NEW ENGLAND PLANTS.

River.	Location.	Use.	Drainage Area. Sq. Mi.	H.P. Wheels.	Approx. Capacity of Wheels. Sec. Ft. per Sq. Mi. (Generally 80% eff.)	Remarks.
Union	Ellsworth, Me.	El. Power	537	3 000	1.06	
Androscoggin	Rumford Falls, Me.	do.	2 090	30 000	1.45	
Saco	W. Buxton, Me.	do.	1 550	4 000	1.15	
Presumpscot	Great Falls, Me.	do.	438	3 500	2.64	
Merrimack	Garvins Falls, N. H.	do.	2 340	6 000	1.00	
Connecticut	Vernon, N. H.	do.	6 300	32 000	1.64	Proposed, 48 000 h.p., or 2.46.
Connecticut	Turners Falls, Mass.	do.	7 100	67 500	2.05	
Winooski	Montpelier, Vt.	do.	196	1 650	1.32	Two adjacent plants, Montpelier and Barre L. & P. Co.
Otter Creek	Near Middlebury, Vt.	do.	650	4 000	2.05	Now under construction.
Leicester	Salisbury, Vt.	do.	30	2 200	4.50	Large storage.
Silver Lake	Near Salisbury, Vt.	do.	19	4 000	3.40	Storage and high head (676 ft.).
Deerfield	Shelburne Falls and above, Mass.	do.	...	52 800	3.80	Average, 4 plants, N. E. P. Co.
Millers	Farley, Mass.	do.	384	435	0.78	Plants of Athol, G. & El. Co.
Millers	Wendell, Mass.	do.	353	2 200	3.27	
Chicopee	Red Bridge, Mass.	Power for Mfg.	664	7 300	2.42	Mfg. jute goods, Ludlow Co.
Merrimack	Lawrence, Mass.	do.	4 452	25 500	2.25	Cotton, woolen, paper mfg., etc.
Kennebec	Madison, Me.	do.	3 200	7 700	0.94	Paper mfg., H. & W. Co.
Penobscot	Millinocket, Me.	do.	1 880	24 600	1.31	Paper mfg., G. N. P. Co.

of the important power installations and a few manufacturing plants.

Reference to Table 1 and Fig. 6 indicates that water-power plants in system, particularly where steam auxiliary is available, show wheel capacities approximating the flow available 25 per cent. of the time. This is illustrated by the Deerfield and Vernon developments of the New England Power Company and several others. Nearly all the hydroelectric stations show wheel capacities in excess of the 50 per cent. flow.

Flow Basis used in Water-Power Estimates.

In the estimates of available water power made by different state commissions there has been considerable latitude in the extent of development assumed. Thus *Maine** used an assumed development for a flow available 60 per cent. of the time (New York — Conservation Commission also using this basis); *Massachusetts*† used the *mean* flow (or approximately the 33 per cent. flow); *New Hampshire*‡ used the 50 per cent. flow.

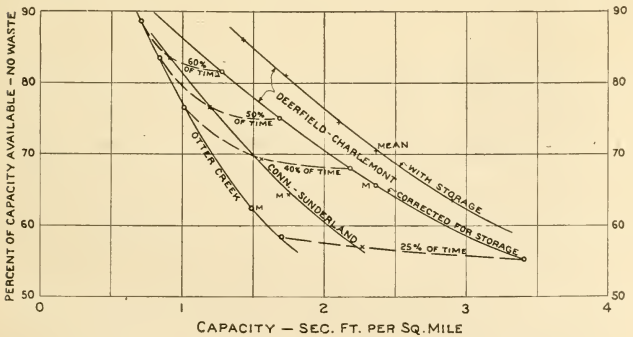


Fig. 7. — Relation of Capacity and Water Available with no Waste of Water.

To better illustrate this matter, Fig. 7 has been prepared, based upon certain curves in Fig. 6. Assumed wheel capacity

* Public Utilities Commission, 1918.
† Commission on Waterways, 1918.
‡ Commission on Water Power, 1918.

is plotted against the per cent. of that capacity available, assuming no water wasted. Limiting curves for Otter Creek (low) and Deerfield River (high), as well as a curve for Connecticut River which is fairly intermediate between the first two, are shown. Dotted lines, approximately horizontal, also indicate capacity expressed as a per cent. of time when available.

For the Connecticut at Sunderland (or the approximate average stream) the following appears from the curve:

Assumed Plant Capacity. (100% L. F.) Sec. Ft. Sq. Mi.	Per Cent. of Time Available.	Average Flow Available, No Waste.		Per Cent. of Time on Duration Curve Corresponding to Previous Column.
		Per Cent. of Capacity.	Sec. Ft. Sq. Mi.	
2.25	25	57	1.28	48
1.75 (mean)	38	65	1.14	52
1.50	40	70	1.05	54
1.20	50	76	0.91	60
0.91	60	87	0.79	65

Thus, without any waste, a river like the Connecticut developed up to the 25 per cent. flow point, will provide about 57 per cent. of that flow, which corresponds numerically to the flow available about 48 per cent. of the time, or 1.28 sec.-ft. per sq. mi. The Deerfield River developed to this same 25 per cent. flow would average about 55 per cent. of its capacity (without waste), or about 2.10 sec.-ft. per sq. mi. (the 40 per cent. flow point), reflecting the higher yield of this stream.

Waste of water — usually expressed as a "utilization factor" — may be considerable where many plants are located on a stream, and there is lack of pondage at or near the plant in question, and may readily amount to from 10 to 25 per cent., or even more in unfavorable cases.

In estimating available water power in general for New England, allowing for the various elements mentioned above, an assumed wheel capacity (at 100 per cent. L. F.) corresponding to the flow available about 40 per cent. of the time seems reasonable,

which would, with the typical duration curve, afford an average output of about 70 per cent. of this capacity, with no allowance for waste of water. If storage is available in considerable amounts, its use will materially increase the percentage of output to capacity of plant, as further noted.

Obviously, in designing new plants, each case must be studied by itself as previously noted, in order to arrive at the proper wheel capacity.

Amount of Water Power in New England.

Basis for Estimates. — Fairly accurate data of the amount of water power, both developed and undeveloped, are available for the states of Maine, New Hampshire and Massachusetts, based upon the following reports:

Maine: Special Report on Water Power, Public Utilities Commission, 1918.

New Hampshire: Report of Commission on Water Power, 1918.

Massachusetts: Report of Waterways Commission, 1918.

For the other New England states estimated amounts of power have been based upon the best information available, consisting of the 1914 U. S. Census of Manufactures, the 1916 Report of the U. S. Forest Service on Electric Power Development, the 1917 U. S. Census Bulletin on Central Electric Light and Power Stations, etc., as well as information gathered by and in the files of the writer.

Developed power is based upon existing wheel capacity, which, particularly in the state of Maine, does not represent the full extent to which sites could be developed. The amount of undeveloped power is adjusted as far as practicable to accord with the flow available 40 per cent. of the average year.

Amount of Water Power by States. — Details of developed and undeveloped water power by states are given in Table 2, where is also shown, for comparison, the total power, including that used for manufacturing and electric power, which would include steam, water and less important prime movers.

As will be noted from Table 2, the developed water power in New England is about 1 170 000 h.p., the undeveloped

867 000, and the total a little over 2 000 000 h.p., averaging about 31 h.p. per square mile of area. The total power, including steam, water, etc., is nearly 5 000 000 h.p., of which almost exactly one half is in use in the state of Massachusetts.

Approximately 25 per cent. of the total power used in New England at the present time consists of water power, and full water-power development would represent only about 40 per cent. of the present total power needs.

The great portion of the undeveloped water power, about 55 per cent., is in the state of Maine, with about 22 per cent. in New Hampshire and the remainder in the other states. The estimates for Vermont of undeveloped power are probably, if anything, too low, as available information is rather meager for this state.

Relative Economy of Water and Steam Power.

Cost of Water Power. — The first cost of a hydroelectric plant (to which type of water-power plant this discussion will be confined) is greater per horse power than that of a steam electric plant, except where the natural opportunities for water-power development are very favorable.

The manner in which a water power is developed, as well as its cost, depends largely upon what may be called "the natural conditions," such as the amount of fall in the river, its degree of concentration, the size of the river or amount of water available for power, the availability of good foundations for a dam and the character of the topography adjacent to the river, with particular reference to the economical location of canals and penstocks.

Where fall is well concentrated and conditions of flowage permit, the simplest and most economical method of development is to build a dam with the power house at one end (or sometimes in the dam itself), simply utilizing the fall developed by the dam. For heads up to the vicinity of 30 ft. such developments can be made with the turbines placed in open wheel pits. Above this amount of head the cost of the bulkhead walls is likely to be such that a more economical development is made by bringing the water through short penstocks (or pipes under pressure) to the wheels. Frequently, natural conditions are

TABLE 2.

NEW ENGLAND — WATER POWER.

State.	Developed H.P.			H.P. Undeveloped.	H.P. Total.	Area Sq. Mi.	H.P. per Sq. Mile of Total Water Power.
	Mfg.	Electric.	Total.				
Me.	250 000	130 000	380 000	482 000	862 000	33 040	26
N. H.	120 000	80 000	200 000	190 000	390 000	9 305	42
Vt.	50 000	70 000	120 000	80 000	200 000	9 565	21
Mass.	200 000	130 000	330 000	80 000	410 000	8 315	49
R. I.	35 000	5 000	40 000	5 000	45 000	1 250	36
Conn.	70 000	30 000	100 000	30 000	130 000	4 990	26
Total	725 000	445 000	1 170 000	867 000	2 037 000	66 465	31

NEW ENGLAND — TOTAL POWER AND POPULATION.

State.	Mfg. Total H.P. 1914.	Elec. Total H.P. 1917.	Total H.P. Mfg. and Elec.	Population, 1920.	Increase in Population, 1910–20. (%)
Me.	487 211	143 796	631 007	768 014	3.5
N. H.	344 093	97 313	441 406	443 083	2.9
Vt.	173 937	82 154	256 091	352 421	1.0
Mass.	1 396 722	1 015 075	2 411 797	3 852 356	14.4
R. I.	269 854	191 171	461 025	604 397	11.4
Conn.	453 812	259 231	713 043	1 380 585	23.9
Total	3 125 629	1 788 740	4 914 369	7 400 856	12.9

such that it is more economical to carry the water in a canal or closed penstock for some distance along the river below the dam, rather than to obtain the full fall by means of the dam. This is likely to be the case where there are limitations to the height of the dam on account of resulting damage due to flowage.

Whether or not such development will be made by means of a canal or penstock depends largely upon the size of the river, viz., the amount of water to be carried. For a large stream (perhaps for quantities of flow in excess of 500 or 600 cu. ft. per sec.) it is usually more economical to use a canal, for the necessary size of penstock required increases quite rapidly with the quantity of water to be carried, and the cost of very large penstocks is relatively much greater than for smaller ones.

With large rivers, however, it is often desirable on account of the topography of the river banks to carry the water the greater part of the distance in a canal with small slope, and then for a short distance in penstocks (usually one for each wheel unit) which drop rapidly from the canal level at its end or " fore bay " to the wheel units at the level of the power house.

The main features of a hydroelectric development may therefore be divided into —

(1) Dam.

(2) Waterways — either canal, penstock or a combination of these.

(3) The power house, including its foundations and tailrace.

(4) The equipment, which may be further subdivided into hydraulic and electrical.

Obviously, the general items which will most affect the cost of a water-power development are those of the dam and waterways (and occasionally the tailrace). Where natural conditions are such that these features of the development can be made at low cost, the resulting total cost of development will be low, as in general the other features (power house and equipment) will vary in cost within a comparatively narrow range.

Cost of Water-Power Developments. — The total cost per horse power of capacity of water-power plants will vary (based on approximate pre-war costs) from about $50 to $60 per horse

power in extremely favorable developments upwards, an upper limit of about $250 per horse power usually resulting in a cost of power output (including fixed charges, operating and transmission costs as further explained) about equal to that of a good-sized modern steam plant. Investigations made for the Public Utilities Commission of the State of Maine in 1918, covering the cost of both developed and undeveloped power on the principal rivers of the state, showed an average cost per horse power developed of about $114, while the undeveloped was estimated at about $99 per horse power. Further details of these estimates are appended hereto (Table 3), which were on the basis of a development to an amount of flow available 60 per cent. of the time after regulation by storage and with a 100 per cent. load factor. It should also be kept in mind that these power sites in Maine are among the best in New England, now undeveloped, and sites in most of the other states will show a much higher cost of development.

Effect of Load Factor on Cost of Development. — We may logically include the cost of dam (including land and water rights) and waterways (and perhaps of power-house foundations and tailrace, if these are features of importance or of unusual construction) in an item which may be called "construction cost" and which reflects particularly the relative advantage or disadvantage of the power site. The remaining costs, which may be called "power house and equipment," will obviously vary almost directly with the extent to which development is made, or more particularly the load factor for which the plant is designed.

To indicate the extent to which load factor affects the first cost of plant, Table 4 has been prepared. In this table extremes in cost of development have been assumed (through a range that would include "war costs") with the usual variation in cost of equipment and power house, and the relative costs of such plants with varying load factors are given with the per cent. increase in cost over that for a load factor of 100 per cent. Through the range of costs given, as will be noted, the increase in cost is approximately 3 to 8 per cent. for 80 per cent. L. F., 12 to 33 per cent. for 50 per cent. L. F., and 28 to 78 per cent. for 30 per cent. L. F.

TABLE 3.

SUMMARY OF COST OF DEVELOPED AND UNDEVELOPED WATER POWER.

RIVER.	60% H.P. OF CAPACITY AFTER STORAGE REGULATION.			COST OF POWER.					
				Developed.		Undeveloped.		Total.	
	At Developed Sites.	At Undeveloped Sites.	At Both.	Per H.P.	Total.	Per H.P.	Total.	Per H.P.	Total.
Presumpscot	16 770	0	16 770	$153	$2 561 000	..	..	$153	$2 561 000
Union	6 530	0	6 530	51	334 000	..	..	51	334 000
Kennebec	63 900	169 560	233 460	150	9 600 000	$100	$17 092 000	114	26 692 000
Androscoggin *	118 020	42 770	160 790	120	14 200 000	134	5 730 000	124	19 930 000
Penobscot	158 310	94 560	252 870	90	14 200 000	76	7 150 000	84	21 350 000
Saco *	30 070	17 070	47 140	130	3 900 000	116	1 978 000	125	5 878 000
Total or Weighted Ave.	393 600	323 960	717 560	$114	$44 795 000	$99	$31 950 000	$107	$76 745 000

* In the state of Maine only.

TABLE 4.

Effect of Load Factor on Cost of Hydroelectric Plants.

Cost of Plant to Deliver 1 H.P. on Wheel Shaft with Different Load Factors						Per Cent. Increase in Cost over that for 100 Per Cent. L. F.		
100 Per Cent. L. F.			80% L. F.	50% L. F.	30 % L. F.			
Equip. and P.H., Etc.	Other Costs.	Total Costs.	Total Cost.	Total Cost.	Total Cost.	80% L.F.	50% L.F.	30% L.F.
$80	$420	$500	$520	$580	$687	4.0	16.0	37.4
70	430	500	518	570	663	3.6	14.0	32.6
60	440	500	515	560	640	3.0	12.0	28.0
60	340	400	415	460	540	3.8	15.0	35.0
50	350	400	412	450	517	3.0	12.5	29.2
60	240	300	315	360	440	5.0	20.0	46.7
50	250	300	312	350	417	4.0	16.7	39.0
50	200	250	262	300	367	4.8	20.0	46.7
40	210	250	260	290	343	4.0	16.0	37.3
30	70	100	108	130	170	8.0	30.0	70.0
20	40	60	65	80	107	8.3	33.3	77.7

TABLE 5.

Fixed Charges for Hydroelectric Plants with Varying Cost of Plant and Load Factor.

Cost of Plant per H.P.		Fixed Charges in Cents per Kw. Hr. of Output at Switchboard.			
		Load Factor.			
Total Cost.	Cost of Equipment and P.H.	100%.	80%.	50%.	30%.
$500	$80	0.82	0.86	0.95	1.13
500	70	0.82	0.85	0.94	1.09
500	60	0.82	0.85	0.92	1.05
400	60	0.66	0.68	0.76	0.89
400	50	0.66	0.68	0.74	0.85
300	60	0.49	0.52	0.59	0.72
300	50	0.49	0.51	0.58	0.69
250	50	0.41	0.43	0.49	0.60
250	40	0.41	0.43	0.48	0.56
100	30	0.16	0.18	0.21	0.28
60	20	0.10	0.11	0.13	0.18

Cost of Power from Hydroelectric Plants. — Fixed charges on the cost of a water-power development, or the basis for annual cost of power, constitute approximately 10 per cent. of the construction cost, the variation being about as follows:

Interest	5 to 6 per cent.
Depreciation	2 to 3 per cent.
Taxes and insurance	1 to 2 per cent.
Total	8 to 11 per cent.

Assuming annual fixed charges at 10 per cent., the cost per kilowatt-hour for 24-hr. 365-day power has been computed and is given in Table 5, using the range in first cost and load factors as noted previously, and assuming water available to full plant capacity at all times, with no waste.

The fixed charges represent the chief item of cost for hydroelectric power at the switchboard. The remaining items of operating costs will not usually exceed 0.10c. per kw.-hr., being less with large plants and high-load factors and greater with the converse of this situation.

On the other hand, it must be kept in mind that a hydroelectric plant on a typical New England stream, without storage, would not deliver its full output for a considerable portion of the average year, depending on the extent of development. Assuming a development up to a flow available 40 per cent. of the time (and 100 per cent. L. F.), as previously shown in Fig. 7, this would for the average stream afford an output of about 70 per cent. of the wheel capacity, without any allowance for water lost due to leakage or waste. (As further noted, this percentage may be very materially bettered by storage regulation.) To allow for waste it would probably be desirable to assume as the output in an average year only about 60 per cent. of the plant capacity instead of 70 per cent., so that fixed charges as given in Table 5 would be increased in the ratio of $\frac{1}{0.60}$, or 1.67.

Comparison with Cost of Steam Power. — This ratio has been applied to the power costs for certain of the plants assumed in Table 5, adding thereto 0.1c. per kw.-hr. for operating costs, and the results given in Table 6 for comparison with the cost

of steam power, using for the latter (Table 7) data presented by Mr. W. F. Uhl.*

Comparing the lowest-cost water power with that of steam power based on $3.00 coal, there is a margin in favor of the water power of about 0.3c. to 0.5c. per kw.-hr. With a steam plant costing $75 per kw. and $5.00 coal, a cost of water-power plant between about $250 and $300 per h.p. results in about the same power cost for both water and steam. The average undeveloped water power in the state of Maine at about $100 per h.p. would have from 0.4c. to 0.7c. per kw.-hr. advantage over steam power, with $5.00 coal.

TABLE 6. — Cost of Water Power.

Plant Cost.	Cost of Water Power at Switchboard in Cents per Kw.-Hr. (a).		
	100% Load Factor.	80% Load Factor.	50% Load Factor.
$500	1.47	1.52	1.68
400	1.20	1.23	1.37
300	0.92	0.97	1.08
250	0.78	0.82	0.92
100	0.37	0.40	0.45
60	0.27	0.28	0.32

TABLE 7. — Cost of Steam Power — (W. F. Uhl — 1918).

Cost of Coal. (Ton of 2 000 Lbs.)	Cost of Power in Cents per Kw.-Hr. 5 000 Kw. Plant Running 8 760 Hrs. Yearly.					
	50% Load Factor.		80% Load Factor.		100% Load Factor.	
	Plant $75 per Kw.	Plant $150 per Kw.	Plant $75 per Kw.	Plant $150 per Kw.	Plant $75 per Kw.	Plant $150 per Kw.
$3.00	0.77	0.99	0.58	0.72	0.49	0.62
4.00	0.91	1.13	0.68	0.83	0.60	0.72
5.00	1.04	1.26	0.80	0.94	0.70	0.82
6.00	1.17	1.39	0.90	1.05	0.80	0.93
8.00	1.44	1.66	1.12	1.27	1.01	1.13
10.00	1.71	1.93	1.34	1.49	1.22	1.34
12.00	1.98	2.20	1.56	1.71	1.43	1.54

* Transactions American Society Mechanical Engineers, 1918.

On the basis of 60 per cent. L. F. — which ought to be obtained (and in a large power system may be materially bettered) — water power will cost from about 0.3c. to 1.0c. per kw.-hr., through the range of cost practicable under normal conditions (viz., up to about $300 per h.p.); steam power will cost a little less than 1c. per kw.-hr. with $5.00 coal — an average margin of, say, about 0.4c. per kw.-hr. in favor of the water power. What the future cost of coal will be is problematical. If it is not to be less than $8.00 per ton, as predicted by some, this would mean, for the conditions just assumed, about $1\frac{1}{3}$c. per kw.-hr. for steam power, which would materially extend the range of feasible cost for water-power developments.

Cost of Transmission. — As most of the remaining attractive water-power sites in New England are situated at a very considerable distance from the present manufacturing centers, to fairly compare the cost of water and steam power, to the former should be added the cost of transmission. This subject was treated by the writer, in collaboration with Prof. Ralph G. Hudson, in his report to the Public Utilities Commission of the State of Maine in 1918, and appended hereto (Table 8) is a tabular extract from that report. As will be noted by reference to these tables, power transmission *in large units*, at a cost of 0.1c. per kw.-hr. or less, is readily obtainable.

Transmission costs would cut the margin in favor of water power for the "average feasible plant" from about 0.4c. down to 0.3c. per kw.-hr., on the basis of approximately normal plant costs, and coal at $5.00 per ton. With coal at $8.00 per ton, the margin in favor of water power would be about 0.6c. per kw.-hr. for the "average feasible plant."

Dependability. — A water power depends upon natural agencies for its supply of power, which will in an unregulated stream be variable in amount, and perhaps require an auxiliary steam plant. Storage and pondage will help materially to equalize seasonal and daily fluctuations in water available for power.

Experience of the past few years has shown that steam power may increase greatly in cost and even fail for lack of coal supply, due to labor and transportation difficulties. Our perspective of

TABLE 8.

ESTIMATED COST OF TRANSMISSION LINES.

Distance. Miles.	Capacity of Line. Kw.	Line Voltage.	Number of Tower Lines.	Number of Wires per Tower.	Total Cost per Mile.
25	5 000	66 000	1	6	$3 500
25	10 000	66 000	1	6	5 000
25	20 000	66 000	1	6	7 000
50	10 000	66 000	1	6	5 000
50	25 000	66 000	2	6	10 000
50	50 000	100 000	2	6	14 000
75	50 000	100 000	2	6	14 000
75	100 000	150 000	2	6	20 000
100	100 000	150 000	2	6	20 000

ESTIMATED COST OF POWER TRANSMISSION.

Length of Line. Miles.	Capacity of Line. Kw.	Total Capital Cost of Line.	Capital Cost per Kw. Transmitted (50 Per Cent. L. F. and 5 Per Cent. Losses).	Cost per Kw.-Hr. (with Annual Cost 25 Per Cent. of First Cost).
25	5 000	$87 500	37	$0.10
25	10 000	125,000	26	0.08
25	20 000	175 000	18	0.05
50	10 000	250 000	53	0.15
50	25 000	500 000	42	0.12
50	50 000	700 000	29	0.08
75	50 000	1 050 000	44	0.13
75	100 000	1 500 000	32	0.09
100	100 000	2 000 000	42	0.12

ANNUAL OPERATING COST OF TRANSMISSION LINES.

(Per cent. of capital invested.)

Interest	7 per cent.
Depreciation	6 per cent.
Operation, maintenance and taxes	12 per cent.
Total	25 per cent.

the relative dependability of water and steam power has thus been materially changed, and the value of water power as a standby, even at greater cost than steam, is now better appreciated. In many cases power cost is but a small percentage of cost of product, so that dependable power even at greater cost is well worth while.

Storage Development.

General Statement. — In the foregoing comparison of cost of water power and steam power a typical New England stream has been assumed without storage, which means that a considerable percentage of the time the flow and available power will be low, and in this respect the water-power plant is at a disadvantage with the steam plant. It is for this reason often desirable on streams where little storage exists to have an auxiliary steam plant to supplement the use of water power, with particular reference to a good output of primary power. Where storage is available at reasonable cost the flow of a stream may be more nearly equalized and the amount of primary power materially bettered.

To illustrate this effect, Fig. 8, was prepared for the Saco River at West Buxton, Me., showing the effect of a total storage of 14 billion cu. ft. on the river above this point. The present duration curve for the Saco River with little or no storage is shown by curve No. 1, while, depending upon the method of operating storage, viz., for best primary power, or using the storage yearly, the duration curve will take the form of curve No. 2 or curve No. 3. The basis for this diagram consisted of a hydrograph study for the period 1908–16, and it will be noted that the primary power if taken at the flow available 95 per cent. of time is increased from that corresponding to a flow of about 0.44 sec.-ft. per square mile to about 1.03 sec.-ft. per square mile, or nearly $2\frac{1}{2}$ times. The average output of a plant developed to a flow available 40 per cent. of the time would also be materially better than for the natural stream. In making the studies of the effect of storage in the state of Maine, a mean of curves No. 2 and No. 3 was assumed as the probable actual method of storage

operation, and with this assumption it will be noted that the required plant capacity would be but little different with the regulated flow, but the flow available during the year with

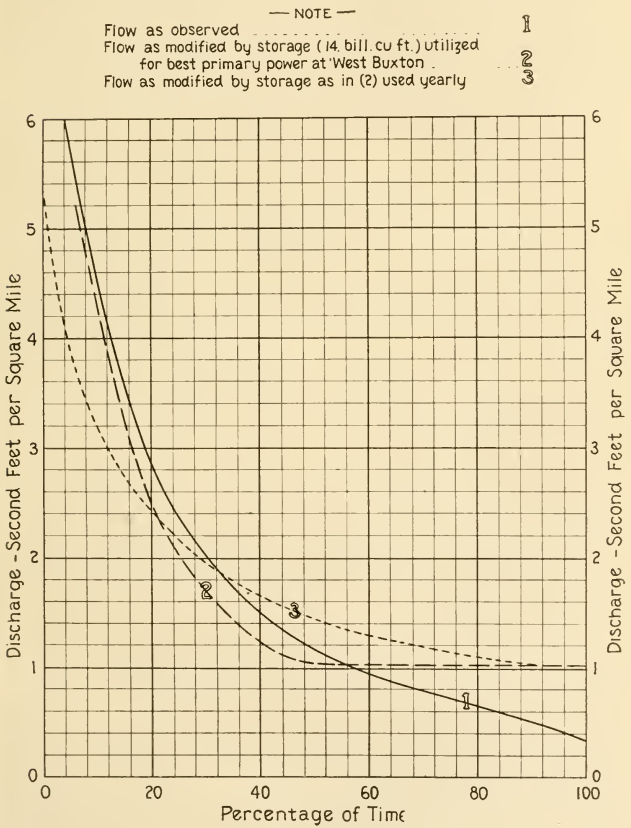


FIG. 8. — SACO RIVER AT WEST BUXTON, ME. FLOW DURATION CURVES, 1908–1916.

storage would be about 84 per cent. of the amount for 40 per cent. flow development instead of only 73 per cent. with the natural flow (curve No. 1).*

Cost of Storage. — The allowable cost of storage will evidently vary for a given river with the number of plants or total head at which the stored water can be utilized. A theoretical limit based upon coal saving may be approximated as follows: Of the cost of steam power a little less than a cent per kilowatt-hour, as previously noted, at a good-sized plant, with 60 per cent. load factor, about 0.6 of a cent would consist of coal cost with coal at $5.00 per ton, or approximately $52.00 per kilowatt-year. One million cubic feet of storage utilized through a head of 1 ft. would give at the switchboard about 1/450 of a kilowatt-year, or 11.5c. per year expressed in coal cost. Capitalized at 10 per cent., the annual cost (interest, depreciation, taxes, repairs, etc.) would be about $1.15, which on this basis could be expended per million cubic feet of storage per foot of fall, provided all of the stored water was utilized. Due often to lack of pondage or control of the water by other plants on the stream the full amount of stored water cannot be utilized. In fact, in many cases this might be as little as one half, or about 56c. per mil. cu. ft. per foot of fall. Taking 50c. as perhaps a limit, it is evident that an available head of 100 ft. would warrant an expenditure of about $50.00 per mil. cu. ft. of storage, 200 ft., $100.00 per mil. cu. ft., etc. This would not include any allowance for the cost of operating storage, which however would seldom be over a few cents per million cubic feet annually per foot of fall.

On a river largely controlled by a single interest, like the Deerfield, less stored water would be wasted and a proportionately greater cost of storage development would be warranted.

Cost of Storage Reservoirs. — In the appended table (Table 9) the estimated costs of storage reservoirs for various rivers in the state of Maine are given, which show an average cost of about $33.00 per mil. cu. ft. For the developed power sites which would utilize these storage reservoirs the cost per million cubic feet per foot of fall would be only about 15c., and including the total available power on these streams the cost would only

TABLE 9.

COST OF INCREASED STORAGE IN MILLION CUBIC FEET PER FOOT OF FALL.

River.	Increased Storage Mil. Cu. Ft.	Total Cost of Increased Storage.	Average (weighted) Head for Storage Use.			Cost of Increased Storage.			
			At Developed Sites. Ft.	At Undeveloped Sites. Ft.	At Both. Ft.	Per Mil. Cu. Ft.	Per M.C.F. per Ft. of Fall.		
							At Developed Sites.	At Undeveloped Sites.	At Both.
Presumpscot.....	14 000	$151 000	250	...	250	$10.79	$0.04	...	$0.04
Union.....	9 150	136 000	78	...	78	14.85	0.19	...	0.19
Kennebec.....	17 060	802 000	185	666	851	47.00	0.25	$0.07	0.06
Androscoggin*....	7 550	200 000	427	213	640	53.60	0 13	0.25	0.08
Penobscot	22 630	447 000	211	284	495	19.70	0.09	0.07	0.04
Saco*.....	10 720	957 000	202	105	307	95.70	0.47	0.91	0.31
Total or Weighted Average.....	81 110	$2 693 000	216	253	469	$33.20	$0.153	$0.131	$0.071

* In the state of Maine only.

be about 7c. per mil. cu. ft. per foot of fall. Conditions in the state of Maine are thus extremely favorable for storage development, and in fact many of the rivers even now have sufficient storage capacity available to materially equalize their flow.

Some data of actual and estimated cost of storage reservoirs in New England and New York are given in the following tables:

Cost of Storage Reservoirs.

Reservoir.	Purpose of Storage.	Cost.	Capacity. Mil. Cu. Ft.	Cost Per Mil. Cu. Ft.
	Constructed.			
Aziscohos, Me.	Power	$1 000 000	9 600	$105
Ripogenus, Me.	do.	1,000 000	25 000	40
Somerset, Deerfield R., Vt.	do.	800 000	2 675	299
Indian River, N. Y.	do.	83 555	4 460	19
Wachusett, Mass.	Water supply	11 021 353	8 760	1 260
Ashokan, N. Y.	do.	12 699 775	16 030	792
	Estimated.			
Portage, Genesee R., N. Y.	Power	4 520 000	11 250	402
Scandaga, N. Y.	do.	4 500 000	29 000	155
Oxbow, Raquette, N. Y.	do.	1 745 000	15 000	116
Saranac Lake, N. Y.	do.	614 000	4 000	154
Harrisville, Oswegatchie, N. Y.	do.	696 000	5 000	139
Black Lake, N. Y.	do.	580 000	6 000	97
Eel Weir Rapids, N. Y.	do.	150 500	11 000	14

Estimated Cost of Proposed Hiram Reservoir on Saco River.
Total storage capacity = 10 000 mill. cu. ft.

Item.	Estimated Cost.	Per Cent. of Total Cost.	Cost per Mil. Cu. Ft.
Construction cost	$329 000	34	$32.90
Land, flowage, etc.	440 000	46	44.00
R. R., roads and bridges, etc.	188 000	20	18.80
Total	$957 000	100	$95.70

Estimated Cost of Proposed Storage Reservoirs on Wood, Attean and Brassua Lakes.

Total storage capacity = 7 340 mil. cu. ft.

Item.	Estimated Cost.	Per Cent. of Total Cost.	Cost Per Mil. Cu. Ft.
Dams, bridges, etc.	$290 000	88	$39.50
Land	40 000	12	5.50
Total	$330 000	100	$45.00

Results from Storage Reservoirs. — One of the most interesting of the reservoirs listed above is the Somerset Reservoir, on the Deerfield River, built in 1912 at a cost of about $300 per mil. cu. ft., the water from which is now being utilized by the New England Power Company through a total developed head of 500 ft., and will, with future possible developments, be available for a total head of over 1 600 ft. The effect of the Somerset Reservoir on the flow of the Deerfield is shown on Fig. 9 in the comparative duration curves at Charlemont, in one case corrected for storage and in the other as observed, including the effect of this storage. On this chart is also shown the natural flow into the Somerset Reservoir, as well as the flow actually released from it. During the five-year period October, 1913, to September, 1919, inclusive, the average amount of water actually released from this reservoir annually has been about 75 per cent. of its capacity.

Possibilities of Storage Development in New England. — Additional storage possibilities in the state of Maine, as appended, aggregate on the principal rivers a total amount of about 81 bil. cu. ft. Considerable opportunity also exists for storage development in the other New England states, although usually at considerably greater cost than in Maine.

In *New Hampshire*, on the Connecticut and its tributaries, there is at present about 9.5 bil. cu. ft. of storage, with about 15 bil. not yet developed. On the Merrimack River and tributaries

about 22 bil. cu. ft. of storage can also be developed, or a total for these two rivers in the state of about 37 bil. cu. ft.* The estimated average cost of 21 of these storage reservoirs on the

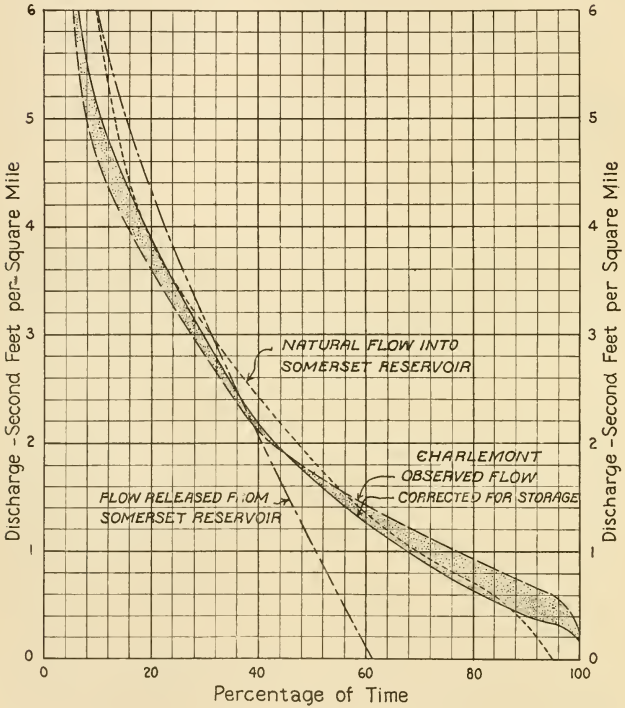


FIG. 9. — DEERFIELD RIVER AT CHARLEMONT, FLOW DURATION CURVES, 1913–14 — 1918–19.

Contoocook River and tributaries, where a total storage capacity of about 9.5 bil. cu. ft. can be obtained, is about $148 per mil. cu. ft. The total coal saving, based on 3 lbs. of coal per kilowatt-

* New Hampshire W. P. Report, 1918.

hour and 80 per cent. efficiency of power plant for the total amount of available storage on the Connecticut and Merrimack and tributaries, is estimated at about 278 000 tons per year, of which about 105 000 tons would be at plants outside of New Hampshire.

In *Vermont* the report of the Vermont Conservation Commission in 1917 shows that nearly 10 bil. cu. ft. of storage can be developed on tributaries of the Connecticut River, Otter Creek and Winooski River, without, however, any data of cost of this development.

In *Massachusetts* the Waterways Commission in 1918 reported that additional storage of about 21.5 bil. cu. ft. could be obtained, the greater portion of it being on tributaries of the Connecticut River and on the Nashua River, but not including the Deerfield River. Data of cost are given for the proposed reservoirs on Millers River, which aggregate about 6.4 bil. cu. ft. and were estimated to have an average cost of $354 per mil. cu. ft. usable through a total head of somewhat over 300 ft. Conditions are not as favorable for storage development in Massachusetts, with the exception of the Deerfield River, as in the northern states. No data are available for *Connecticut* or *Rhode Island*.

Difficulties of Storage Projects. — Where a storage reservoir is located on a stream with many different owners of water power, it is often difficult to get all to contribute toward the cost of the storage development and its maintenance and operation. In the case of the Deerfield River, as already noted, nearly the entire stream is controlled by one company and the total amount of fall is so great that storage is both practicable and desirable. In the case of the Androscoggin River in Maine, largely through the efforts of Mr. Walter H. Sawyer, C. E., the Aziscohos Reservoir on the Magalloway River, in the headwaters of the Androscoggin, was built in 1911, affording a storage capacity of about 9.5 bil. cu. ft. of water. This was financed by the four large users of power on the river, viz., the Union Water Power Company, the Berlin Mills Company, the International Paper Company, and the Rumford Falls Power Company, by agreement whereby each company purchased stock in the Aziscohos

Reservoir Company equal to one fourth of the expense of organization and of construction of the new dam. These companies also participate in the use and cost of stored water from the Rangeley Lake system, and the result of all this storage has been a great improvement in the flow of the Androscoggin, it now being possible to maintain not less than 1 550 cu. ft. per second at Berlin, N. H. (or 1.15 sec.-ft. per sq. mi.). The actual operation of this storage since the construction of the Aziscohos Reservoir has shown somewhat better results than this amount. It will be noted, however, that this storage project has been possible because four large coöperating companies control a sufficient amount of power on the river to make the storage worth while.

Under the Mill Act here in New England, which is essentially the same in the different states, the supreme courts have frequently decided that the erection of a mill dam for the purpose of creating water power for manufacturing and industrial purposes is of public use and benefit and that the owners of such a dam may be given the right to flow land above the dam upon payment of proper damages therefor. It is not at all clear that the scope of this act extends and covers storage reservoirs, even though they be for the purpose of improving the flow of the river and therefore water power use. The lack of a legal basis whereby land and flowage rights may be taken in order to construct storage developments and the further lack of authority to collect tolls, or the cost of storage improvement and its operation, from owners along a stream, are two of the most serious obstacles which at present are retarding storage developments here in New England, as well as in many other portions of the country.

Redevelopment of Water Power.

Many of our water-power developments in New England date back to the middle of the past century, and even earlier. They are consequently in many cases laid out so as to utilize only partly the entire amount of available power. This has often been due to the manner in which in the olden days a good fall was divided into a number of smaller falls, with the

consequent duplication of leakage, canal and tailrace losses, etc. There are many cases where it would be feasible, and in fact a good return could be obtained upon the investment, to make a redevelopment along modern lines.

The water-power development at Holyoke is a good example of the older type of development in several falls, with a large space occupied by canals. From an engineering point of view this could readily be redeveloped in one fall, with a substantial saving in power. The various long-time leases of power, however, held by many different mills represent a serious difficulty in any such redevelopment. There are, however, several of these older developments in New England which sooner or later, as land and power costs increase, may be redeveloped.

At Bellows Falls on the Connecticut River is an old development where there is a large amount of leakage and waste of power. The New England Power Company, which now control this privilege, have in mind a redevelopment which will add very considerably to the power output from this site.

Another site which could be redeveloped and show a much greater power output is Penacook, N. H., on the Contoocook River, where a fall of about 100 ft. can readily be developed, replacing several poorly developed and wasteful plants now located at this point.

Another important feature of improvement is the installation of modern turbines. Progress during the last decade in improving water wheels has been marked, and actual tests of wheels showing as high as 93 per cent. efficiency are not uncommon. Under reasonably good conditions working efficiencies of 85 per cent. or even better can be obtained, which is probably 15 to 20 per cent. better than that of the average New England plant with old wheels. Where power is in demand any increase in wheel efficiency means practically a proportionate increase in income or earning power of the plant. The importance therefore of adding 15 to 20 per cent. to output is obvious.

The two methods of increasing available water power by improving the plant layout and installing modern wheels are of sufficient importance to warrant a careful investigation and report on this subject, as has been done in respect to the development of power sites by several states.

The Future of Water-Power Development in New England.

Lower Costs. — The figures presented of the amount of water power as compared with total power requirements show clearly that our total power needs would consume all the available water power in New England at the present time, provided this was feasible commercially and from the point of view of transmission of power. The figures presented do not include the amount of power used by locomotives, which is already a field invaded by water power, — notably in the West.

The extent to which the cost of coal has increased, as well as the great difficulty in obtaining it in many cases, even at prohibitively high cost, point unmistakably to the need of a comprehensive water-power development for New England, taken as a whole. Keeping in mind dependability as previously noted, water-power costs, particularly on streams where storage can be made available, will be justifiable, even though somewhat in excess of the cost of steam power.

Construction costs for the last two years or more have been prohibitive of all but emergency work, and only a small amount of water-power construction has been going on during this time. There is, however, indication of a break in costs of materials and labor at the present time, and it is reasonable to suppose that perhaps in the near future construction of some of the necessary power projects may be started.

Transmission of Water Power beyond State Lines. — As has been noted, the greater portion of the undeveloped water power in New England lies in the state of Maine. At the present time a state law prevents the transmission of this power outside the state boundary. On Fig. 10 is a map of New England showing the main transmission lines, with particular reference to use of water power; also distances in an air line from Boston. It will be noted that the greater part of the undeveloped water power in both the states of Maine and New Hampshire is within possible transmission of eastern Massachusetts, where of course large amounts of power could be utilized.

The extent to which state lines should interfere with the free use of a natural resource like water power is a broad question,

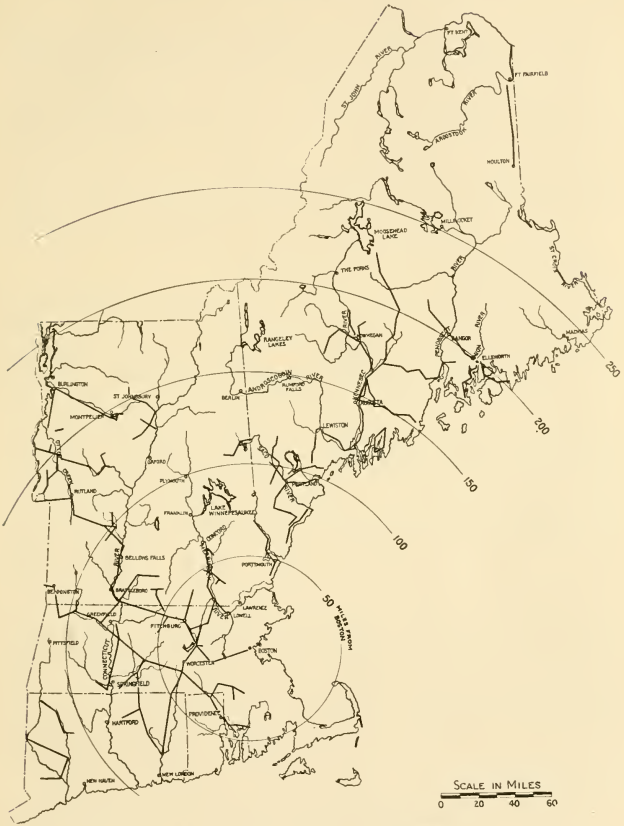


FIG. 10. — NEW ENGLAND POWER TRANSMISSION LINES.

and one in regard to which public opinion has probably changed somewhat during the eleven years that this Maine law has been in operation. The theory underlying this law was said to be that industries would be attracted to the state by the cheap

water power. This tendency has, however, apparently been offset by transportation difficulties. Would it not be wiser for the state of Maine to permit the leasing of a portion of its surplus undeveloped water power over a sufficient term of years to make this worth while to an investor, allowing it to be transmitted to the great power market in southern New England? As an illustration of what this might mean, 100 000 kw. of power from the Kennebec River and its general vicinity could be transmitted to eastern Massachusetts at low cost per kilowatt-hour and tied in with the comprehensive power system of the New England Power Company and other companies.

A low rental charge per kilowatt-year might be required for such power going from the state. This rental, together with the increased amount of taxable property, would afford a source of revenue to the state where at present practically no return is obtained. The lease should include proper provision with respect to use of power within the state when this becomes necessary in the future. There would also be a distinct advantage in a continuous transmission line between the states of Massachusetts and Maine, for such a line and its connections would have a greatly diversified field of supply of both steam and water power, and more favorable operating conditions and a better output would result.

The same general situation is true with reference to New Hampshire, which has a considerable amount of undeveloped power not usable at the present time. In fact, taking New England as a whole, the ideal situation from the point of view of power would be to forget state lines and look upon it as a single area or unit. It is not so large in area but that interconnected main transmission lines could readily reach all except perhaps northern Maine.

Storage. — The difficulties in the way of development of storage have already been outlined. In Wisconsin, a river regulation act for the Wisconsin River was passed in 1907, and a company has built and is operating storage reservoirs on this stream, assessing tolls upon the various power owners. In this case, however, it was brought about by the unanimous consent of parties in interest, power of eminent domain in acquiring the

land and water rights being given, based largely upon public use or benefit due to effect upon navigation.

New York has quite an elaborate act, passed in 1916, creating storage reservoir districts as municipal corporations with power of eminent domain, and collecting the contributions from down-stream owners in the form of taxes. Under this act the regulating district on Black River has been formed. No reservoirs have yet been built, however, nor has the law been tested in any court decision.

Here in Massachusetts several attempts have been made to procure legislation giving right of eminent domain in storage projects and in assessing tolls upon owners along the stream. As yet, however, no definite action has been taken by the legislature in adopting such an act. Legislation on this matter is also under consideration in several other states.

Public opinion seems to be shaping itself toward measures by the states whereby water storage may be effectively planned, carried out and operated under some form of state supervision (and possibly in some cases with the aid of the state). Comprehensive and workable legislation along this line is one of the most important needs to effect a more complete water-power development here in New England.

Federal Water-Power Commission. — The scope of the work of the Federal Water-Power Commission which was established by Congress at its last session is based fundamentally upon the improvement of navigation, navigable waters being defined as " those over which Congress has jurisdiction under its authority to regulate commerce with foreign nations and among the several States," this referring to rivers in either their natural or improved condition and (notwithstanding interruptions by falls or rapids) which are used, or are suitable, in interstate or foreign commerce. Just how far the scope of this commission's work will affect our New England streams is not clear. A stream like the Connecticut River, for example, is navigable in its lower portions and is an interstate stream. Technically, storage projects on the upper main river, as well as on any tributary, affect this navigability, and in fact there are few of the larger streams in New England which are not navigable to some extent as defined by this act.

Provision is made in the Federal Water-Power bill whereby the right of eminent domain can be invoked in storage projects and in assessing tolls. The extent to which this may apply in New England, however (except perhaps in such cases as Windsor Locks, on the navigable portion of the Connecticut River), is questionable, as much will depend upon the breadth of interpretation of the control of navigable waters assumed by the Federal Power Commission and developed by court decisions.

Concluding. — To summarize the situation briefly:

1. New England has about 2 million h.p. of water power, a little over half of which is developed.

2. Over half of the undeveloped water power is in the state of Maine, and about one fourth in New Hampshire. Only about one sixth is in southern New England.

3. A portion of this undeveloped water power is too expensive — even with costs again somewhere near the normal — to warrant development. Much of it would be worth while developing, in view of a probable permanent increase to some extent in cost of coal, over the old normal figures, provided a market for power was at hand.

4. The great power demand is in the southern three states — particularly Massachusetts, which could absorb much of the water power from the northern states if available.

5. A state law in Maine now prevents the transmission of water power beyond the state lines, and therefore the early use of a large part of the best undeveloped water power in New England.

6. The amount, reliability and value of water power can in many cases be greatly increased by storage developments. At present these are in most cases impossible because of lack of power to take land and water rights, as well as to distribute the construction and operating costs equitably.

7. The best use of the water-power resources of New England would be possible by disregarding state lines or looking at the six states as a unit. A comprehensive power transmission system could then practically interconnect the greater part of New England, with great resultant advantage in dependability of power, better load factors and power output.

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PAPERS AND DISCUSSIONS

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THE ST. LAWRENCE RIVER PROJECT.

By Henry I. Harriman.*

(Presented December 17, 1920.)

In my capacity as a member of the Massachusetts Commission on Foreign and Domestic Commerce, my attention has been called in the last few months to a proposal which has come from the West, relative to the opening of the St. Lawrence River to navigation. As you know, the Great Lakes span about one thousand miles in the heart of North America. It is one thousand miles from Duluth to Buffalo, and in that region reside about 40 per cent. of the total population of the United States. It is a region rich in agriculture, rich in minerals and thickly populated. Ninety per cent. of our iron ore comes from the shores of the largest of the Great Lakes, — Lake Superior; much of our copper, coal, wheat and other grains come from this fertile region, and some of our greatest manufacturing cities are found there. In the last thirty years there has grown up on those lakes a commerce greater than the combined commerce of the Mediterranean and the Black seas. More vessels pass through the locks between Lake Superior and Lake Huron than pass through the Suez and Panama canals combined. This great traffic of the lakes moves eastward until it comes to Buffalo, and from that point it must be transferred to trains and finish the journey to the seaboard by rail. This causes a breaking of bulk at Buffalo, and means a more expensive form of transportation, so it is no

* 50 Congress Street, Boston, Mass.

wonder that the West, attempting this tremendous traffic and commerce and tremendous agricultural and manufacturing intercourse, is asking that the sea be opened to the Great Lakes.

There are two natural obstacles that lie between the eastern end of Lake Erie and sea level in the St. Lawrence. One is Niagara Falls and the other the rapids of the St. Lawrence River. There has been a shallow canal for many years around both of these obstacles, but it was so small that it really served little commercial purpose. About two years before the outbreak of the war a crusade was started to build the new Welland Canal around Niagara Falls. That is nearly completed — probably it will be finished within four or five years — and will make it possible for boats drawing 22 to 26 ft. of water to pass from Lake Erie to Lake Ontario. There will then be but one obstacle, — that is, the rapids of the St. Lawrence River. And now from the West, from 15 western states officially represented, there has come the demand to Congress that this river be made navigable, in order that the traffic of the lakes may get directly to the ocean, and they are waging a very active campaign. I am not here to discuss the problem from the standpoint of the West, they are fully capable of presenting their own needs, but it seems to me that the project promises much to New England.

At first blush it seemed that it might be a detriment to our section of the country, because of the possible ill effect upon foreign commerce, but more complete study has convinced me that it has even greater promise for the East than for the West. If the St. Lawrence River is canalized it will be by the construction of a series of dams across the river, — possibly a dam and a canal in some sections, — but in any event much of the river will be dammed, and that means it will be possible to develop at the ends of these dams created for navigation purposes very great power plants and make available for the United States, for Canada and New York State a really unthinkable amount of power. The flow of the St. Lawrence River has been carefully gaged for over sixty years, and is given on the best authority at about 241 000 sec.-ft. The flow is extremely uniform, because the Great Lakes serve as a huge equalizing reservoir. The minimum and maximum flows vary less than 25 per cent. from

the mean, and if certain projects which engineers have suggested are carried out for the creating of a dam on the Niagara River, which will raise the level of Lake Erie about 3 or 4 ft., this will still further equalize the flow of the St. Lawrence and make the variation not over 10 per cent. So the flow is perhaps the most uniform of any large river in the world. The St. Lawrence River drains one fourth of North America, and in its course falls 221 ft. In the 113 miles along the international boundary the fall is 91 ft., and in the 70 miles of rapids above Montreal there is an additional fall of 130 ft. It is proposed that the entire river be developed for the joint use of the two nations. While Canada will not of course be able to entirely alienate any portion of the power within her boundaries, she has consented to make long-time leases for export of power from that section of the river which she owns. From the international section our country will be entitled to one half of the power. Engineers estimate, and I think conservatively, that if the St. Lawrence is canalized and the power developed, it will be possible to generate 4 million h.p. from the river, and that is equivalent to the energy which could be produced from 24 million tons of coal burned in the most modern and efficient steam plant, or of 36 million tons burned under the boilers of an average New England mill. So that gives you the tremendous possibility that there is for power in this river. That power translated into kilowatts per hour means that the St. Lawrence River is capable of developing about 26 billion kw.-hr., which can be transmitted from the St. Lawrence River and delivered at substations in New England, Canada and New York State. If we assume that by direct ownership and treaty right America has the privilege of using half of that power, we would have at least 13 billion kw.; and if New England gets behind that project, as it should, it should have half America's share. Of necessity, the market of this power is limited to New England, New York, Canada and possibly a small section of New Jersey. Thus far it has not been found feasible to transmit power over 300 miles, and the 300-mile circuit passes just outside of Boston. It takes in a portion of New England, the entire state of New York, half of New Jersey and a little section of Pennsylvania. So we are in a natural geographical position to

use at least half of the portion of the power which America should be entitled to, — one quarter of the whole. We should be able to have here, when the power is completely developed, about 6 billion kw.-hr.

I should like very briefly to discuss with you what the power requirements of New England are. The utilities of New England to-day are generating about 2 billion kw.-hr., but it is fair to assume that fully one fourth of that power now comes from water, and therefore we may assume, for the sake of argument, that the utilities can use about 1½ billions of this St. Lawrence power. The railroads should be and will be electrified in the near future, and there are 5 000 miles of railroads in New England. But 1 500 miles of railroad transport 80 per cent. of the tonnage of New England railroads, and so it is only necessary to electrify about 1 500 miles of road in order to handle the great bulk of the railroad tonnage of this section. For instance, the Fitchburg Division of the Boston & Maine handles nearly 40 per cent. of that system's total tonnage. The railroads of New England are using about 6 million tons of coal a year, and if 80 per cent. could be replaced by electric power, it would be true that electricity was replacing about 5 million tons of coal. That coal last year cost New England railroads nearly 50 million dollars. If they had bought St. Lawrence River power at 1c. per kw. the cost of energy represented by 5 million tons of coal would have been about 18 million dollars, — a saving of nearly 30 million dollars, — and a few years' saving would have paid for the electrification of those 1 500 miles of road, including the purchase of the locomotives, track structure and substations. If that saving had been effected it would have been equal to 3 per cent. on all of the outstanding bonds and stocks of all the New England railroads. So you see the tremendous possibility in the electrification of our railroads. The problem is not as complicated as it might at the first blush appear, because a great percentage of the tonnage is hauled over a small percentage of the rails. There are many pieces of track that will probably never be electrified, but those 1 500 miles that bear heavy traffic will, in my opinion, be electrified; and, when they are, the St. Lawrence River can be assumed to supply a sufficient energy to operate

them. That would take another 2 billion kw. So the railways, electric light companies, trolleys, etc., would out of 6 billion kw.-hrs. take about 3½ billion. That leaves a balance of 2½ billion for industry. Let's see what the demands of New England industries are. I have absolutely no authentic information on that. The number of spindles in New England cotton mills is approximately 18 500 000, — 22 spindles per h.p. being a fair allowance. The number of spindles in the woolen mills is 2 199 999, with 4 200 cards, probably requiring about 200 000 h.p. The cotton mills now use about one billion kilowatt-hours, and about 25 per cent. of this now comes from water. The woolen mills require not over 175 000 000 kw.-hrs. Without going into the details of the other industries, like paper, brass, rubber and machine shops, I think it is fair to say that 2 billion kw.-hrs. would be all the power generated by water that New England industries now require, and therefore the St. Lawrence power would be sufficient to supply our railroads and utilities and industries and still leave us one-half billion kilowatts to draw on, and when I say St. Lawrence power I mean merely one quarter of the power, which I believe, from the geographical situation, New England is entitled to.

Now, a word as to the cost of power. A commission of engineers representing both governments is making a careful study of the situation. The best information we have to-day is that the dams themselves, and the locks, but not including the power houses — that portion having directly to do with navigation — will cost 300 million dollars, and if that figure is correct, one mill per kw.-hr. will equal the interest charge, and will also create a sinking fund which will return to the two governments their expenditures, within thirty-five years. I don't know how much the power houses and power plants are going to cost, but we all know that a development of that size, with the heads involved, are cheap developments to build, and I believe it is fair to say that the power can be transmitted and delivered wholesale in the New England states at materially less than 1c. per kw.-hr. — how much less I don't want to prophesy, though probably materially less. And when you consider what it means for New England industries to be freed from the bugaboo of coal, and at

an expense not more than that of $3 or $4 coal, I think you will agree that the St. Lawrence development has advantages. I am not quite so optimistic as Professor Barrows in his assumption that we shall return to $5 coal. I believe New England is going to pay from $7 to $9 for its coal in the future. The present freight rate is substantially $5, and I see nothing in sight to indicate a lower freight rate by rail, though there may be somewhat lower water rates in the future, and I don't believe we shall get a better price than $7 to $8 in this region, and if that is so the St. Lawrence power means a great deal to the industry and the people of the New England states.

So much for the power possibilities of the project. I am only going to touch on two other considerations. First, its effect on our domestic commerce, and second, its effect upon our foreign commerce. We are a great manufacturing section. We import from other states large supplies of raw materials, convert them to finished products and ship them to other sections of the world. We import most of our foodstuffs. Six million tons of food products come into these same New England states, for domestic consumption, each year; four million tons of raw materials, also. There is a tremendous domestic commerce that now moves in and out of New England solely by rail.

By rule of thumb it was always said that you could move a ton of material 5 miles by water for the same price that you could move it 1 mile by rail. That ratio was upset during the war, because of the ravages of the submarine, but water rates are rapidly falling and rail rates are increasing, and shippers say to-day that the old ratio of 5 to 1 as between water and rail now holds good. From Buffalo to Boston by rail is 500 miles. The distance via the St. Lawrence, through Lake Ontario and around Niagara Falls, is 1 400 miles, — a ratio of 3 to 1; and I submit that if 5 to 1 is the ratio between the water and rail rates, 3 to 1 means a less cost by water. The ratio between water and rail in Chicago is a little over 2 to 1. That opening of the St. Lawrence will mean boat lines from the ocean shores to the Great Lakes; it will bring in foreign stuff and send out manufactured articles less than is done now by rail. The objection has been raised that the railroads will lose. In answer, traffic is doubling every

fifteen years. It will be at least ten years before this project is finished. It will be the heavy materials that will be taken from the railroads and put on the boats, and instead of a detriment to the railroads it will be a help to them. President Smith of the New York Central believes it will save them millions and millions of dollars in investment in terminals and tracks, if the bulk of the heavy traffic, which pays relatively poorly, is taken from the railroads and they are left to carry that class of material which pays them a better rate.

As to our foreign commerce, there are some of you who feel that much of the traffic which now moves through eastern points will go directly by boat from the lakes to Europe. That may be true. But, even if it is true, I believe that the advantages of the project far outweigh any disadvantages.

The project has the backing of men like Mr. Hoover, Ex-Secretary Lane, — men from various sections of the country, who have studied it and who believe it will not work any lasting harm to any of our eastern points. Of course Buffalo will object to losing the transfer charge which she now has. Naturally, New York State, after building the Erie Canal, will feel that some of the burden will be taken from the canal to the river. New York and Buffalo may lose a little; but isn't the situation about the same as that one hundred years ago, when the power loom was invented and when the weavers in Lancashire destroyed the first mill that had power looms in it? And that power loom has made Manchester the greatest manufacturing center in the world. So sometimes things which seem to be detrimental often work out to our good, and I believe that whatever is a real benefit to the whole country will benefit our foreign commerce. Therefore, if I may sum up the situation, it seems to me that the project offers the solution of our fuel problem. In the first place, it offers us cheaper freight on food and raw materials and manufactured materials, and in the second place possible damage to our foreign commerce will far more than be outweighed by increase in prosperity of our section, through the benefits that will come in the other two ways.

MEMOIR OF DECEASED MEMBER.

LOAMMI FRANKLIN BALDWIN.*

Loammi Franklin Baldwin was born in Naples, Ill., November 6, 1849. He was the son of Loammi 3d and Helen Avery Baldwin, and descended from a distinguished line of ancestors. He was grandson of Major Benjamin Franklin Baldwin, and great grandson of Col. Loammi Baldwin, the eminent engineer and public-spirited citizen who was active in the projection and construction of the Middlesex Canal extending from Lowell to Boston, and in 1826 made an examination and report to the Massachusetts legislature of a system of inland waterways across the state from Boston to the Connecticut and Hudson rivers. Colonel Baldwin was interested in the study of the native fruit-bearing trees and discovered and improved by propagation the Baldwin apple, which was named for him. He commanded the 26th Regiment of Continental troops in the war of the American Revolution. Mr. Baldwin was also a nephew of James Fowle Baldwin, the first president of the Boston Society of Civil Engineers. He was educated in the public schools of Lawrence, Mass., and at Immanuel Hall, Chicago.

In the year 1869 he was employed as rodman on the Champaign and Decatur Railroad in Illinois, and later was rodman on the construction of the Connecticut River Railroad between Hartford and Saybrook, Conn. In 1870 he attended the Massachusetts Institute of Technology, taking the civil engineering course, and left at the end of his third year. In 1873 he became a member of the firm of Coolidge & Baldwin, engaged in general engineering in Lawrence, Mass., and served as assistant engineer on the construction of the Lawrence Water Works until its completion. In 1877 he entered the employ of the Essex Company, and was engaged in hydraulic construction mill work and chimney designs. From 1880 to 1884 he was engaged on geological survey work as principal assistant to James E. Mills, a

* Memoir prepared by Richard A. Hale and James R. Baldwin.

prominent mining engineer, at Mine La Motte, Mo., and Plumas County, Calif., preparatory to placer gold mining there. In 1885 he was chief engineer for the Mohawk Valley Lumber Company, running a preliminary line for their railroad from Long Valley over Beckwith Pass to Sierra Valley in Nevada and California.

Returning east in 1886 he was engaged in construction of mills and hydraulic structures for the late Hon. William A. Russell, who had large paper mill interests in Bellows Falls, Vt., and Mt. Tom and Lawrence, Mass. In 1891 he entered the inspection department of the Associated Factory Mutual Fire Insurance Companies of Boston as engineer and special inspector, remaining with them until his retirement from business on account of ill health in 1915.

In 1873 he married Kate W. Richardson, of Peabody, Mass., who survives him together with two daughters, Miss Clara and Miss Mary, and a son, James Rumford Baldwin, who is a civil engineer with the Essex Company.

Mr. Baldwin was a member of the Boston Society of Civil Engineers, Massachusetts Institute of Technology Alumni Association, Rumford Historical Association, Sons of the American Revolution, National Historical Society and the Woburn Phalanx Association.

He resided in the old Baldwin House in Woburn, built in 1661, which has been changed but slightly from the original construction, and is a noted historic landmark in Woburn, near the statue erected in memory of Col. Loammi Baldwin.

He attended the Episcopal Church, and while in Lawrence took an active part in Grace Church affairs, and was a warm and intimate friend of Bishop Lawrence, who was rector in Lawrence at that time. A large map of the Holy Land painted on the walls of the Parish House was the work of Mr. Baldwin, and has been used in Sunday-school work since that time. He died May 10, 1920, after a long illness.

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RAT EXTERMINATION AND PROOFING WITH RELATION TO THE PREVENTION OF PLAGUE.

By L. L. Williams,* Past Asst. Surgeon, U. S. Public Health Service.

(Presented before the Sanitary Section, January 5, 1921.)

I am not going to attempt to tell the entire story of plague, because it could not be done in our limited time, and would hardly serve any good purpose. I appreciate that I am speaking to a society of engineers who presumably, from their calling, would be interested in the more technical side of the subject, — rat-proofing; but you would hardly get anything from the discussion unless you knew the reasons which underlie such work. It is hard to understand rat-proofing unless you know something of the habits of rats and of plague. So I will attempt to outline the habits of plague and the habits of rats, in order that you can get the salient points, because in rat-proofing the physician and the plague expert can tell the engineer the object to be attained, and then they are dependent on the engineer to devise the best means of securing that objective. So far, most of the plague work has been done by physicians, and but little by engineers. A great many of the engineering experiments, even, have been carried out by physicians, and as they know but little about engineering principles most of the first work was decidedly experimental.

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Plague is a peculiar disease and develops in waves. There are a few places in the world that have always been infected, or since the earliest known times. These are principally the east and west slopes of the Himalayas, between India and China, Central Arabia and Central Africa. Those are the endemic centers. Plague epidemics are great travelers and in the old days they used to go by caravans. The slow-moving caravan was a community in itself and, as it moved along, carried rats with it. In later days, plague has mostly traveled by ships. I am going to speak of the travel of plague before I speak of its transmission. Plague starts from its endemic centers in a fairly mild form, but as it spreads it becomes more virulent. When the epidemic commences perhaps 3 out of every 10 attacked die. While at its height, as a rule about 8 out of 10 die, showing that it gets stronger as it goes on. That is not only true of each place attacked but is true also as it increases in any given place. In India, for example, it may start with 3 000, 5 000, and 20 000, the next year going to 30 000, then to half a million, and in some cases to a million in a year. In later years the mortality appears to fall off. Plague takes years to spread. Many epidemics have taken as many as twenty-five or thirty years or more. The present plague — pandemic (I call it " pandemic " because it is world-wide) — commenced years ago on the east or west slopes of the Himalaya Mountains; then it reached the port of Hongkong, which was the first port to report a case, in 1894. There was no further plague reported for a few years. Then it spread into Japan, its salient characteristic being that it attacked ports. Very few inland cities got it. Within a few years it was recognized in India, mostly in the ports such as Bombay, Rangoon, etc. Within six years — that is, up to 1900 — a chart of plague would show ports infected in a very large portion of the world. From these points plague spread along shipping routes to the larger coastal cities of China, Japan and India, the east coast, the west coast, the Red Sea and the Mediterranean coast of Africa, and then into the other Mediterranean ports, and about 1899 the east coast of South America, Brazil and Argentina; then on the west coast of South America as far south as Antofagasta and north to Peru; then to San Francisco

in 1900. Quite a stir was made at that time, but unfortunately the seriousness of the trouble was not recognized. Instead of trying to eradicate it an attempt was made to hide it. So it commenced to infect the counties around San Francisco, and California is now an endemic center. Infected animals are there being picked up, and a program for eradicating the disease has been formulated. It is hoped that this will be effected within twenty years. In 1914 the plague had reached New Orleans, and by the summer of 1920, Galveston, Beaumont and Pensacola. The plague has also, at one time and another, infected Liverpool, Glasgow, London, and recently Paris. It is a matter of geographical evidence, by which those who have studied it predict that plague is due to infect one or more of the south or north Atlantic ports within the next decade, and it behooves the Atlantic ports to be prepared for it.

Plague as a disease of man is one thing and as an infection of a port is another. Plague as a disease of man, under present sanitary conditions, is not such a dread disease in civilized communities. In San Francisco the total number never reached as many as 300. In New Orleans there are not yet 100 cases, but in India it still runs in tens and almost hundreds of thousands in a year.

The carrier of plague is the rat flea, by which the disease is carried from rat to rat. There are four or more different types of rat flea. The characteristic that interests us is that the rat flea prefers the rat to any other host. When the plague is pretty prevalent among the rats, and they are dying in large numbers, then the flea gets onto the mice, human beings, and other animals. The rats like our homes and our foods, and many die in or close to houses. Fleas leave a dead rat with amazing speed, and if there are not enough rats or mice to house the fleas they get on to human beings. It has been estimated that plague is a disease of rats in any town at least six months before human beings have it. When plague appeared in New Orleans everybody quarantined against the city, but ships had been coming from New Orleans to other ports for the previous six months without quarantine measures, because no one knew of the presence of plague. That may have been the time other ports

received their infection. Paris has reported about 200 cases of human plague. They have been for some time talking about "Disease No. 9," which we now think is plague. As Paris is not a port and about the only shipping is by barges, which are not transatlantic boats, the question is raised as to how the plague entered Paris. It may be that there is some near-by infected port that is not saying anything about it, yet is plague-infected and sending barges to Paris. Since the war a great many places in Europe are keeping very quiet about their disease situation, and we have no means of knowing how many ships from infected ports are coming into Boston.

In India, animals are more or less worshiped by the natives. In a large part of India their religion teaches that the souls of their ancestors return to the earth in animals. They believe that rats have souls; and in a large part of India they object to rats being killed, and will put out a portion of their food to feed the rat population. That explains the extent of the plague as a disease of man in India. It is not so bad in other parts of the world, unless the bubonic type changes to the pneumonic. In the pneumonic form it attacks the lungs of those infected, with a mortality of about 98 per cent. There is probably a much greater chance of plague, once it becomes an infection of man, taking the pneumonic form in cold climates rather than in the southern climates. It is unfortunate that when plague attacks in northern climates it may change to the pneumonic form, in which case it becomes almost uncontrollable.

When plague attacks a port it is a serious thing, from an economic standpoint. In the first place, there is quarantine. Every civilized port quarantines against the infected place. New Orleans' loss was in excess of $15 000 000. In the second place, there is a great avoidance of shipping. If Boston was infected and all the ports were quarantined against ships leaving this city, how much easier for a boat to put into New York or Fall River, or some place not infected, and thus escape quarantine! In the first few months of plague in New Orleans the waterfront was almost deserted. After some time, and with preventive and control measures under way, shipping commenced to return, but not as before until the epidemic in New Orleans was well under control.

Then we have the cost of rat extermination which is not a cheap matter. There is probably at least one rat for every human being in the city. In the country there are probably 8 or 10 for every person. If you know the population of Boston you can estimate the population of rats. Plague in Boston would mean, inside of five years, the catching of upwards of 2 or 3 million rats. If it is assumed that the rat-trapper receives about $100 a month, and above his expenses also receives 10 cents additional for every rat he brings in, some idea of the cost may be obtained.

In addition, rat-proofing is necessary to stop them from finding nesting places. In normal times, when food is fairly abundant and nesting places are easy to find, a female rat will bring forth its young from 8 to 10 times a year, and there are usually from 8 to 12 rats in each litter. Each female commences reproducing at the age of about two months. If there are over two million rats in the city, and in one year's time one million are caught, at the end of the year probably very close to the original population will still remain, provided rat-catching were the only measure instituted. The rat-catcher will probably have done almost no good whatever. It has been noticed that where the food supply is cut off the litters average only from 2 to 4 per year, and the number per litter 2 to 5, instead of 8 to 12. If nesting places are made less available the number of litters falls off, but the number per litter is not affected. The food supply can be handled by proper garbage disposal. This makes it necessary to enforce ordinances for metal-tight garbage cans and rigid rat-proofing of all food-handling establishments. Making it difficult to obtain food and nesting places through rat-proofing of all buildings in the town will do more to eliminate the rat menace than all the rat-trapping that could possibly be done.

As perhaps you know, there is quite a movement on foot to start rat surveys in New England ports, and Massachusetts seems to be taking the lead. There is a reasonable expectation that a substantial appropriation will be made to carry on the work in every port in Massachusetts and Rhode Island. Maine and Connecticut are expected to follow suit. New York City,

Philadelphia, Savannah, Jacksonville and other Atlantic and Gulf ports have commenced work.

Of course the rat survey is to find out if there are any infected rodents and to continue to catch and examine for infection in order to pick up the plague in the rat population before it begins to attack human beings. That means rat extermination and also rat-proofing. Under emergency conditions the cost of those things runs up to three or four times what it would if you are in a position to proceed slowly and systematically. If we find infection among the rats it will very probably be along the water front, and intensive measures only would be necessary for perhaps one or two city squares. Exactly the same measures, but covering the whole city, would be necessary if you wait for a human case. The rat survey will not prevent infection of the rats, but will serve to keep it from human beings. With this comes the necessity for rat-proofing, upon which rests the prevention of spread of plague. If the rat-proofing were 100 per cent efficient in a port, there would be very small chance of plague entering and almost no chance of its becoming an epidemic among human beings. One shining example is Liverpool, where almost all of the water front is of masonry construction, which is rat-proof. The result is that when a case of plague appears to-day on the water front in Liverpool, it does not result in quarantine against Liverpool, as there is small chance of rats invading the city and thus causing an epidemic. Rat-proofing, to prevent nesting facilities and make access to food establishments difficult, is a vital measure in preventing plague.

At New Orleans this has been done, and more recently in Galveston and Beaumont. The houses are divided into food establishments and non-food establishments, each having different regulations. Every food establishment must build a concrete floor at least 4 ins. thick and surrounded with a concrete wall extending at least 2 ft. into the ground and at least 1 ft. above the flood level. It is known in New Orleans that a rat practically never burrows more than 2 ft. underground to make a nest. In many of the houses with masonry foundations and either wood or adobe construction above, it is not unusual at all to set this masonry construction 1 ft. above the ground.

Wherever it is less than 1 ft. often rat holes will be seen above the masonry, where apparently there was no foothold for the rat to climb up. How they make their initial boring, I do not know.

For rat-proofing purposes, rats are divided into two classes, — the Norway and the *alex-rattus*. There are three main types of rats, — *Mus norvegicus*, *Mus alexandrinus*, *and Mus rattus*. The Norway rat — gray, dirty and repulsive — is the largest. As a general rule the rat, including its tail, is not over 12 ins. long, though I have seen them longer. The *alexandrinus* and the *rattus* are very similar but pretty, being built on graceful lines, with long, thin tails. The *alexandrinus* is a blue-gray rat, with white belly and a long tail. The *rattus* is similar in shape but black in color. The thing that groups the *alexandrinus* and the *rattus* together is their common enemy, the Norway. He will not permit any other rat to live in his surroundings, and will even attack cats. In New Orleans we found that sometimes they killed off the cats. As the Norway is a ground rat, their preference is to find a good, solid floor and then bore under the edge of it and back under the floor. That is the reason why rat-proof floors must have chain walls going down 2 ft. into the ground. The Norway rat wants to bore under something that gives good protection above. Apparently he doesn't want rain to come into his nest. The *alex-rattus* is now known as the "roof rat," having been driven off the ground by the Norway. He preferably makes his home between double walls in an attic, or between the ceiling of one room and the floor of the room above He likes any dark place when he can get to it readily. He wants protection for his nest; wants to get between partitions in a house. The Norway rat in southern climates (I don't know the best methods of rat-proofing in northern climates) is best kept out by means of the concrete chain wall.

Dr. Creel, soon after 1914, when the survey first started, tried to find what would keep rats out. He could get no information on the subject, so he built concrete cylinders of varying strengths of concrete. He took a strong concrete mixture such as is allowable in any building, and had the foreman make a cylinder 3 ins. thick and 2 or 3 ft. across — in which they im-

prisoned Norway rats. In forty-eight hours nothing but a rat hole was left. However, he found that $3\frac{1}{2}$ ins. of concrete, if faced with $\frac{1}{2}$ in. of smooth cement, would stop them, hence the specifications call for 4 ins. of concrete flooring, faced with smooth cement. The wall should be at least 4 ins. thick, of similar construction, to go not less than 2 ft. into the ground, and extend 1 ft. above the floor, and to have no openings. It was not specified how steam or water pipes should go through, because the proper method was not known. That was left to the plumbers and engineers, who had a hard time of it. One man, who put steam pipes through a new foundation to his own home, found that when the steam was admitted the walls cracked, and he was summoned for not having rat-proof construction. I understand that the pipes are allowed to be surrounded with any material which is rat-proof. If holes appear, a change to something else must be made. In most cases pipes are surrounded with soft cement or asphalt. The best method of all is to put a collar of galvanized iron wire around the pipe, held close to the pipe with a band, and spreading out on the wall, and attached thereto in some fashion. It has been found that $\frac{1}{2}$ in. mesh is the largest that can be allowed, and it must be at least 12-gage. Rats have been known to gnaw through lighter construction.

The problem of the home in New Orleans, where they are not addicted to cellars, is a serious one. Most of the houses, which are some 20 ft. apart, were raised 18 ins., — set on underpinning, the rubbish underneath cleaned out and three sides left open. That let in plenty of light, which discourages rats. But that method I do not believe is applicable in northern climates to any very great extent, on account of the effect of low temperature under a house elevated 18 ins. and having three sides open. The frame house in New Orleans, as well as in Boston, is another problem on account of double walls. Usually the owner may do one of two things, — either close the double walls, so that the rats cannot get between them, or tear out one of the walls. The latter was the prevalent method in New Orleans. But in northern climates the double wall makes good insulation for warmth in winter.

If there are cracks in the walls or floor they must be attended to. Rats will get in at the edges and the corners. A rat does not like to gnaw a hole in the middle of the floor. You will find the hole on the edge, where the wall and floor come together, or in corners. There are various methods of protecting against that mode of entrance. In food establishments it is required that these double walls shall be filled in from the floor upwards for a distance of 12 ins., with concrete or other masonry set in mortar, or else a mixture of asphalt tar and cinders, making the lower part of the double wall solid. Under these conditions no rats will gnaw in. The other method is by so-called flashing. The best materials are zinc, galvanized iron, or a good grade of tin. It was found that in all dwellings where there were wooden floors and double walls it was necessary to line the entire floor and wall junction with flashing of a good thick metal rather closely tacked down, to stand up from the floor at least 4 ins. and out from the wall at least 4 ins. That did not always prevent rat holes, but in almost all cases there was a smaller percentage and it was ruled that that would be sufficient. Lately, other methods have been suggested. In New Orleans, as well as in the quarantined towns, concrete and metal have been insisted upon as almost the only rat-proofing materials. Since a sanitary engineer has been connected with the work other methods have been devised which are cheaper than concrete. One is by the use of expanded metal, especially for floors in food establishments. Mr. Allen, whom I have seen recently, says that expanded metal with $\frac{3}{4}$-in. cup expanded to $\frac{1}{2}$ in., set between thin planking or embedded in thin concrete, is just as good rat-proofing material as the best concrete. He has also stated that galvanized iron wire, even thin galvanized iron wire, or any good grade of wire if dipped in creosote, when placed between planking is just as good rat-proofing as 4 ins. of concrete. Strange to say, since rat-proofing has been going on, those are the only things that have been suggested as efficient to keep out rats. I do not know whether any other means can be devised in Massachusetts. I am afraid that is one of the things that will be up to the sanitary engineers and the architects. If it can be discovered I believe you can do it.

Another point concerns the rat-proofing of docks. Strange to say, although the epidemic in New Orleans broke out in 1914 it was not until 1920 that rat proofing of the docks of New Orleans was undertaken, except in a temporary and limited fashion. Lately larger and larger appropriations are being made for this purpose. In the beginning it was claimed that the only method of rat-proofing docks was to open entirely that part over water. The dock must be of a single thickness, and it must not be closed with sheet-piling at the edge as that will enclose the dock and make a rat harbor. All that part of the dock over land should be of concrete, and the floor should have a chain wall at least 2 ft. deep around the edge of the floor — all of this made for very expensive construction. As you know, docks are, to a great extent, built on made land, and concrete floors on made land must be rather heavily reinforced. It was found that in putting in a chain wall for these docks it was necessary to go beyond the regulation in order to get a suitable foundation, and that cost money. The cheapest construction that could be devised was interlocking concrete piles in lieu of chain wall. They proved perfectly effective and held their position well, and were much cheaper than laying concrete quite a distance below the water level.

In Galveston one other thing has been allowed, which has proved entirely effective. This has the trade name of Uvella. It is apparently an asphalt rock and is laid down 5 ins. thick. No rat was ever known to find his way through it.

Rat-proofing is primarily to drive the rat out of his harboring place. That is essential in the control of the rat population. To drive the rat out you must consider both the Norway and the *alex-rattus* rats. The Norway rat wants to get under the floor, and sheds with concrete floors, or even concrete walks, may serve. For all of these you must thrust a retaining wall 2 ft. down into the ground. In New Orleans most people tore up their walks, leaving the ground bare. For *alex-rattus* you must eliminate all unnecessary waste spaces. Double walls must be filled up or protected at the edges and corners, that the rat cannot gnaw his way in, and all openings in the wall must be protected, either by filling up with some fairly hard material through which the rat cannot gnaw, or by putting metal gratings across it.

In closing I might say to all of you in Massachusetts that if the plague comes into Boston I believe you are going to have a difficult piece of work on your hands.

DISCUSSION.

H. C. Mosman.* — I do not know that I can add anything to what Dr. Williams has said. He was ahead of me in New Orleans, and when I got there he had the subject pretty well studied.

I was sent to the Gulf coast states by the State Department of Health, to study rat-catching and rat-proofing. Of course southern is much different from northern construction. Houses and buildings in the South are nearly all set on piles, with a lot of lattice work around the front. In the North there are cellars with walls built up for the house to set on, so that rat-proofing here would be nothing to what it is in the South. Down there I heard a great many people, when told they would have to rat-proof, object to the expense, and there was much adverse comment. But after the work was done they told how they had improved their property and were quite satisfied.

Dana Somes.† — We have been protected in Boston by the building law pretty well, for a good many years, on rat-proofing, and do not get rats inside our houses very much. I was interested in what Dr. Williams said about rats not going down more than 2 ft.

I have had a personal experience recently with rats in the Charles Street region, where a new sewer is being built. All through there they formerly had no particular trouble from rats; since they have been digging a perfect plague of rats has been in evidence. Where do those rats come from? Do they live in the drains or way down underground, or where do they come from? We see them in the streets where we never saw them before. That seems to argue that Boston is fairly well rat-proofed, that we never see them at other times — that is, in the buildings. I wonder what measures could be taken to get them

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out of the sewers, which are 8 ft. or so below ground. Just how much of a menace is that?

Dr. Williams. — The reason for the 2-ft. drop of the chain walls in New Orleans is on account of the elevation above sea level. Along the Gulf coast the elevations are put on the railroad stations. Such elevation records as 4 ft., 6 ft., $5\frac{1}{2}$ ft. will be seen. New Orleans is about elevation — 3 ft. Galveston is practically at sea level, and by going down 2 ft. water-bearing strata is reached. I suspect that is the reason they do not go deeper than 2 ft. In Beaumont the 2-ft. drop was not entirely effective. This is a region of gumbo, — black, waxy mud, — and rats were found there burrowing as deep as 6 ft. Whether in Boston it would be necessary to go down 2 or 10 or 12 ft. remains to be seen. If some rats will burrow very deep, that does not show that the majority will. The rules have to be made to fit the majority.

The rats will use sewers as passageways; and where sewers are broken, especially sewer connections in houses, they are used as a means for entering houses.

When you see rats with your own eyes on the streets you have a walloping big invasion of rats. The rat is a night-traveling animal. Rats have large bristles sticking out from the nose, and used as feelers. To catch a rat put the trap close to the runway, not in the middle of the floor, as he will go around, not straight across a room. For most of his route he is running so that his bristles touch the wall, as he goes by feel. All rat-catchers put their traps close to where they know the rat is going. They see indications of rats where they don't see rats themselves. For the Norway rat his hole should be seen, and then more or less traveled paths leading to it can be found. Where the hole is in the wall it will be noticed that the edges of the hole are grayed by the oil from the rat's fur. If the hole is clean it is reasonably certain that it isn't used by a Norway rat. In the case of house rats the rafters should be inspected, because wherever a house rat goes under a rafter he must clasp it and swing down, and so on the wall under the edge of the rafter is a crescent-shaped gray mark left by his oil. That is an absolute sign of the *alex-rattus*. We have been in warehouses where it was declared

that a rat had never been seen, yet under every rafter was the little gray mark. We got 15 or 20 rats the next morning.

H. P. Eddy.* — I'd like to ask Dr. Williams if in our northern buildings, provided our basement or cellar is protected and there are no holes that come in above the floor that we can see, if the remainder of the house above is sufficiently protected? There is no apparent way to get in unless they climb the wall on the outside, and I assume he can't climb more than 18 ins. above the ground.

Dr. Williams. — The Norway seldom does, but the *alexrattus* will. He will climb up the walls or gutter pipes, and if he finds an opening he will go right in, and if you have double walls he will nest there just as long as there is food. To get rid of him, trap him, and close all means of entrance into the double walls to keep him from nesting. That is the only thing that can be done.

The infection of the mice is apparently in the same class as infection of man. It only occurs when the epidemic is so great among rats that the rats have died off, so that there are not enough hosts for the fleas; then they get on the mice and infect them at about the same time they get on man. In New Orleans it was noticed where they were examining about 3 000 rats in the laboratory a day, that as the curve of infection of the rats went up it was not until it was half way to the peak that infection of mice commenced, and when the curve came down to about the half-way point the infection of mice ceased. Also, all infected mice that have been caught have been in buildings that have either before or subsequently shown infected plague rats. Infected mice have never been found without a very heavy epidemic among the rats, and as the epidemic subsided among the rats it disappeared in the mice entirely. The flea attacks other animals besides the mice.

In San Francisco it got among the ground squirrels, and about eight counties have been infected, squirrels dying of the infection. It also has been known to attack the raccoon, possum, guinea-pigs and some other animals. I don't believe cats or dogs are ever attacked. The mongoose has been infected in

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India, and some other small animals. I don't believe larger animals have been affected. In making the curative serum the horse is used, and given a large shot of infection which makes him sick for a day or so, but he practically always recovers.

One of the rat fleas is a dog flea, — *Canis*, and it apparently carries plague. About four types of fleas commonly infested the rats at New Orleans, and all, so far as we know, carried plague. They were found pretty commonly on all the rats, and some of those fleas were found also on dogs and possums.

All rats are not overrun with fleas, however. The average number of fleas per rat in New Orleans, at the height, was only 2 fleas to the rat, and when I left, $1\frac{1}{2}$ fleas per rat. Somebody asked if fleas got into the laboratory, and if a man then ran any danger of infection. Whereas those rats outside seldom yielded more than 2 fleas to the rat, a rat loose in the laboratory for a week or more seldom yielded less than 60 to 80 fleas.

For examination it is necessary to get a live rat. A tray and a saucer of water (about 3 ft. in diameter) is prepared and the rat hit on the head and then put on the tray. Usually it is not over 30 seconds before the fleas jump out and are drowned.

The plague is often fatal to the rat, but unfortunately a lot get over it, and apparently some remain infected for years. Probably it is migration of rats suffering from chronic plague that carries the disease. Any one that kills and examines a rat with acute plague can readily see whether it was going to recover or die very quickly.

Besides the prevention of plague there are added reasons for rat-proofing. It has been estimated it costs about $1.87 a year to feed each rat in the United States. This is the minimum value for the minimum amount of food that will support a rat for 365 days. It is reasonable to suppose he gets away with $1.87 worth of food. In a grain bin he destroys perhaps ten times as much food as he eats. It has been estimated that rats are costing the United States $500 000 000 a year, and that is a conservative estimate. Any one who is handling foodstuffs — grain or hides — knows this. Rats are mighty fond of hides, and will do a lot of damage. It is worth while as a business move for any one who has perishable material to exterminate

them. I believe in a few years the lessened depredation of rats would repay him.

The matter of stored vegetables in the cellar has been mentioned.

I know that is a problem, and I don't believe economically you can entirely keep them from rats. I don't care how closely you rat-proof a building you can't entirely eradicate them. Some are going to come in every now and then. Take the rat-proofing in stables, for instance; it is required to keep grain in bins lined with metal and kept locked all the time. That is the only thing that keeps rats out of feed bins in the stables. If you want to be sure to keep vegetables away from rats, keep them in a bin. It is, of course, useless to suspend it from the ceiling. I'll guarantee an *alex-rattus* will crawl across the ceiling and come down the sustaining rope. I've seen garlic hung from strings from the ceiling and yet were gnawed by rats; frequently you will see where the rats have been feeding on bananas hung from the ceiling.

Disks, if they stand at least 12 ins. in every direction and fit closely on the rope, will prevent the passage of rats. When these are applied to mooring hawsers they are not always effective because they are often placed up the rope only as far as a man can reach, and the rat can jump as far as that.

The use of poison has been mentioned. In New Orleans barium carbonate is used, mixed with any substance that will make a paste, and spread on bread. It is necessary to replace it every afternoon with fresh bait, and in every case it is placed in sewers or well-guarded places. The indiscriminate use of poison is strongly opposed. It was desired of course to examine all the rats, and if they had been poisoned they would have crawled off and died where they could not be found.

MEMOIR OF DECEASED MEMBER.

WILLIAM M. BROWN.*

William Maxwell Brown was born in Warwick, R. I., on August 13, 1854, the son of William M. and Susan Allen (Clapp) Brown.

In June, 1885, he was married to Julia Ida Daniels, of Bangor, Me.; he had no children.

He died in Newark, N. J., May 29, 1920.

The following is an outline of his notable engineering career. He prepared for college at the Riverpoint, R. I., High School and entered Brown University in 1870, graduating in 1873 with the degree of Ph.B. In July of the same year he became a student in the Engineering Department of the Providence, R. I., Water Works. In 1874–76, he was assistant engineer in the office of the city engineer, Providence, R. I.; 1876–77, resident engineer on extension of water works, Brookline, Mass.; 1878–84, assistant to H. A. Carson on day-work construction on the Boston Main Drainage Works; 1884–86, assistant engineer of the Massachusetts Drainage Commission, of which E. C. Clarke was chief engineer. In 1886–87, Mr. Brown was chief engineer of the water works of Westerly, R. I.; 1887–89, assistant engineer of the Massachusetts State Board of Health on investigations for sewerage of the Mystic and Charles River valleys.

In 1889, the Commonwealth of Massachusetts appointed a commission for the construction of the Metropolitan Sewerage System for Boston and its numerous adjacent cities and towns. Mr. Carson, chief engineer of this commission, called Mr. Brown as assistant engineer of construction. This work brought out the executive and professional abilities of Mr. Brown, who soon was placed in general charge of the various sewer contract sections, except the main outlet and those in close connection with the estuaries and river siphons. Upon the resignation of the chief engineer, in 1895, Mr. Brown was appointed superintendent of maintenance and chief engineer of construction of the system. Soon the growing needs of the district called for the extension of

* Memoir prepared by Howard A. Carson, Frederick D. Smith and Henry T. Stiff.

the system into the Neponset valley. Mr. Brown recommended the construction of a trunk sewer for the valley, and during the years 1897 and 1898 its construction was carried to a successful conclusion.

In 1899, Mr. Brown reported upon the project of a high-level sewer to intercept the higher areas of Metropolitan Boston south of the Charles River. This project had been previously suggested as a relief measure by the engineers of the city of Boston, with disposal works on Moon Island. Mr. Brown's studies convinced him that the point of disposal into the harbor at Moon Island would soon prove inadequate for the growing needs of the South Metropolitan District. He, therefore, recommended that the sewage be discharged into the strong tidal currents of Boston Harbor, off Nut Island in Quincy. As advised in this report, the legislature authorized the construction of the high-level sewer. This work was designed on more liberal lines than had been any of the previous sewers in the vicinity, a departure that has been fully justified by the development of the district.

The Metropolitan Water Board and the Board of Metropolitan Sewerage Commissioners were consolidated in 1901, and Mr. Brown was retained as chief engineer of sewerage works under the newly formed Metropolitan Water and Sewerage Board, which position he held until he resigned in February, 1912.

As early as 1901, Mr. Brown became interested in the study of a trunk sewer for the cities and towns of the Passaic valley in New Jersey. At that time he was associated with Messrs. Rudolph Hering and J. J. R. Croes, of New York, in reviewing results of former engineering studies for this work. On December 2, 1901, the consulting engineers recommended in their report "that a union of all the communities which contribute to the pollution of the Passaic valley is desirable; that a trunk sewer system from Paterson to the southerly boundary of Newark be constructed; and that provision be made for the joint disposal of the polluted waters in New York Bay near Robbins Reef." Other studies were made during the years 1902 to 1907, with which Mr. Brown had occasional connection. In the latter year the Passaic Valley Sewerage Commissioners were appointed, and

further studies in detail were made under their instructions by Rudolph Hering and George W. Fuller. The whole project was then referred by the commissioners to William M. Brown, Allen Hazen and Edlow W. Harrison, for a final review. These engineers, who were to report individually, concurred in the opinion that the design as submitted contemplating the disposal of sewerage into New York Bay was the most efficient and economical method for the purification of the Passaic River. Mr. Brown's report is dated January 27, 1908. During the years 1909 to 1911, inclusive, detailed surveys and extensive engineering investigations were made, and detailed drawings were prepared, under the direction of Edlow W. Harrison as chief engineer, all in preparation for construction.

This project was similar in many respects to the Metropolitan Sewerage System of Boston, with the construction of which Mr. Brown had been so intimately connected. When in 1912 the Passaic Valley Sewerage Commissioners were ready to begin the building of their great undertaking it was natural and most fitting that Mr. Brown should be called to carry out the construction work. On February 21, 1912, he resigned his position with the Metropolitan Water and Sewerage Board of Massachusetts to accept the position of chief engineer of the Passaic Valley Sewerage Commissioners. The Metropolitan Water and Sewerage Board thereupon passed a vote of recognition of its indebtedness to Mr. Brown, a part of which vote reads as follows:

"His service of more than sixteen years in charge of the building and operation of these systems has displayed a large constructive ability and an intimate knowledge of the details of maintenance. Faithful devotion and prompt execution and accomplishment have characterized the performance of all his duties."

There is evidence that prior to 1890 Mr. Brown did engineering work — not mentioned in the foregoing outline — on mill construction in Lawrence, Mass.; on the Orange, N. J., Sewerage System; on water works in Wellington, Kans., and in Corning, N. Y.

Mr. Brown was elected a member of the American Society of Civil Engineers in 1896, and in 1893 of the Boston Society of Civil Engineers, and a director of the latter society in the years 1901 and 1902. He was a member of the school board of Chelsea, Mass., from 1899 to 1903, and a member of the Boston Chamber of Commerce in 1910.

Mr. Brown had at the time of his death nearly completed the Passaic Valley Sewerage System. His great works will stand as enduring monuments of his ability. His integrity was beyond dispute; his insistence on good work assured lasting construction. Strong in his determination that the municipality should get the class of work it specified, yet with a judicial weighing of the rights of both contracting parties, Mr. Brown obtained results which reflect his genius and energy.

His consideration for the welfare of his assistants promoted a most friendly spirit. The kindly advice given to others when asked for won for him a host of grateful fellow-engineers. It can be truly said that he left the world greatly indebted to him; and his name will long remain in the memory of many admiring engineers and associates.

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THE NEW METHODS OF PROPORTIONING CONCRETE IN THEORY AND PRACTICE.

By Roderick B. Young.*

(Presented January 26, 1921.)

In the last few years extensive and systematic experimental studies have been made upon concrete and its constituent materials. These have resulted in important discoveries and additions to our knowledge of the properties of concrete, especially as to what governs a proper combination of its constituents, — cement, aggregate and water. Some progress has already been made in applying these new discoveries in a practical way, and it is the purpose of the speaker to describe the steps taken along this line and the results so far obtained by the concern with which he is connected.

The first of the discoveries referred to is the water-cement-ratio-strength relation developed by Prof. Duff A. Abrams of the Lewis Institute, Chicago. Abrams claims that for mixtures of concrete materials with aggregates from a given source, the strength depends on only one factor, the ratio of water to cement, called for convenience the "water-cement ratio"; that this relation holds so long as the concrete is workable and that the character of the aggregate makes little difference so long as it is clean and not structurally deficient. This relationship was first illustrated by the data from which Fig. 1 is derived, which covers

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a series of tests of 6 x 12 in. cylinders of sand and gravel concrete using aggregates of different grading, made into mixes of different proportions and of various consistencies. All results of tests on concrete mixtures having consistencies dry beyond the point of workability have purposely been omitted from the curve.

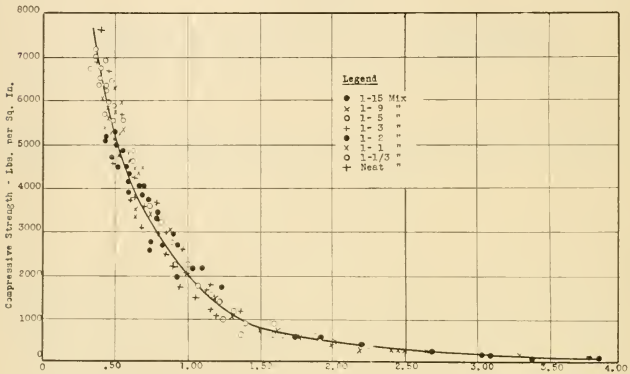


FIG. 1. — RELATION BETWEEN WATER-CEMENT RATIO AND COMPRESSIVE STRENGTH OF CONCRETE (ABRAMS).

One would judge from the foregoing that the relationship was independent of grading, consistency and proportions so long as these fall within practicable limits. This is not so. With cement and aggregate from the same source the relationship varies with all three and in a very definite manner. Instead of the relationship being a simple one, it is the reverse, and concerning which but little is as yet known. A full discussion of the water-cement-ratio-strength relationship is beyond the scope of this paper and would be highly technical and of little interest except to specialists. However, the relationship is of such great practical value in proportioning concrete that we will discuss briefly some of its peculiarities.

For the sake of simplicity the speaker has prepared a series of hypothetical curves showing the characteristics of the varia-

tions where the effect of each of the three variables, grading, consistency and proportions, is studied. These curves are based on actual data but are not to be taken as general, as other conditions than here assumed might alter both their form and sequence.

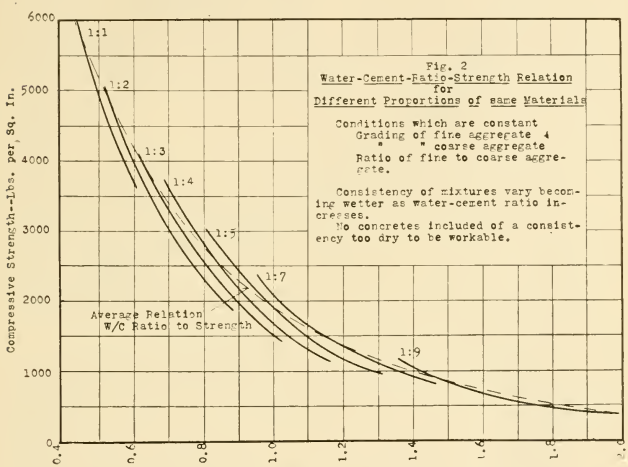


FIG. 2. — VARIATIONS IN WATER-CEMENT-RATIO-STRENGTH RELATION FOR DIFFERENT PROPORTIONS OF SAME MATERIALS. (HYPOTHETICAL CURVES.)

Fig. 2 shows the type of curve which results where aggregates of the same grading are mixed in different proportions. The curve of each proportion is made up necessarily of concrete mixtures of different consistencies but contains no concretes so dry as to be unworkable. These curves are seldom coincident, and then only for short distances, but they not infrequently intersect.

Fig. 3 shows the type of curve which results when the points of equal consistency or workability in Fig. 2 are joined. These new curves represent concretes of equal consistency which have

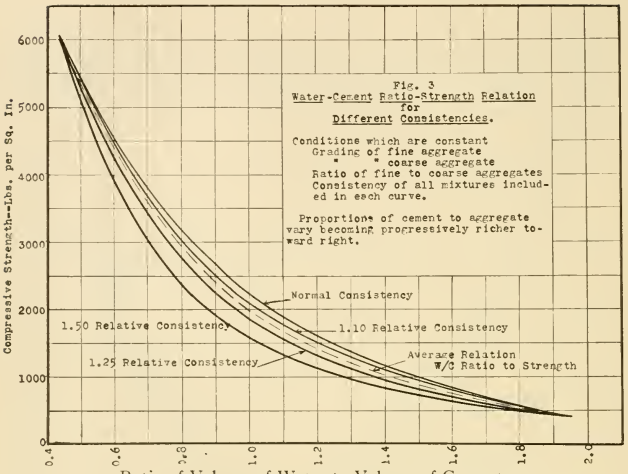


FIG. 3. — VARIATION IN WATER-CEMENT-RATIO-STRENGTH RELATION FOR DIFFERENT CONSISTENCIES. (HYPOTHETICAL CURVES.)

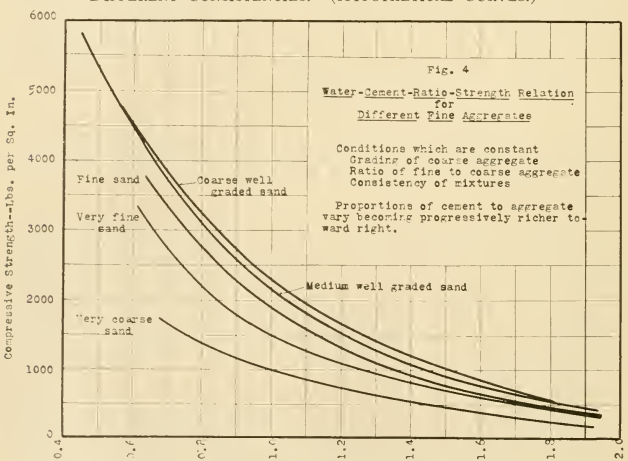


FIG. 4. — VARIATION IN WATER-CEMENT-RATIO-STRENGTH RELATION FOR DIFFERENT FINE AGGREGATES. (HYPOTHETICAL CURVES.)

been made from aggregates the same both in character and gradation. The proportions of cement to aggregate vary for each curve from very lean mixtures at the extreme right to very rich mixtures at the extreme left.

Fig. 4 shows the type of curve which results where fine aggregates of different grading are made up with different proportions of cement and aggregate to form mixtures of the same consistency. In general, well-graded sands of similar minerological characteristics though of different mechanical analyses will not vary greatly in strength for equal water-cement ratios. As sands increase in fineness or coarseness there is a falling off in strength, the relative loss in strength being different under different circumstances. It must be borne in mind in considering these curves that mixtures of equal water-cement ratio are not of the same proportions of cement and aggregate and that therefore the relative economy of different sands cannot be obtained from a consideration of these curves alone.

Fig. 5 shows the type of curve which results where concretes of the same consistency and proportions are used but having the ratio of fine to coarse aggregate varying. The mixtures at the left of each curve contain an excess of sand as ordinarily considered, the oversanding of the mix decreasing toward the right. This particular chart would illustrate an extreme condition where the fine aggregate was a very fine sand; with well-graded concrete sands the curves tend to flatten out and become coincident.

If these last four charts and others like them covering a variety of gradings, consistency and proportions, were combined, the result would be an area in which the major portion of each curve would lie and which could be approximated by a single curve. This is what has happened in Fig. 1, where the multiplicity of tests included has obscured the fundamental variations to which the water-cement ratio is subject.

How, then, can this relationship which is so complex be of any practical value? It is because of the fact that, within the range of grading, consistency and proportions ordinarily met with on any one piece of work, the variation of strength for any one water-cement ratio is not ordinarily sufficiently great to result in

serious error, and while the relationship is variable it is possible to use it in practical work to proportion mixtures which can be predicted to give compressive strengths of the value sought. Therefore, despite the fact that the water-cement-ratio-strength relation is unreliable in many particulars, it offers a means of

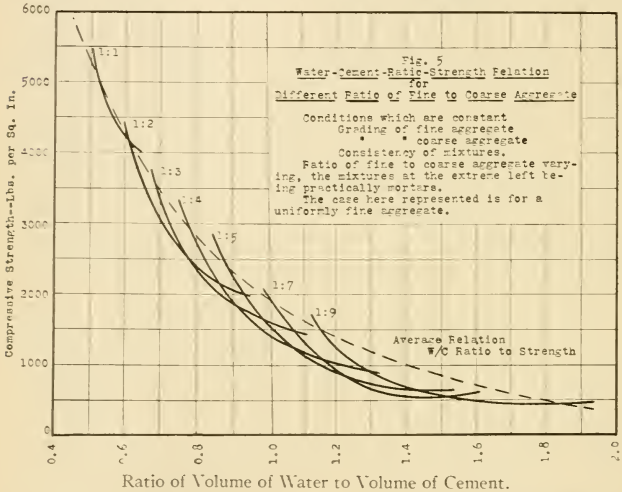


FIG. 5. — VARIATION IN WATER-CEMENT-RATIO-STRENGTH RELATION FOR DIFFERENT RATIO OF FINE TO COARSE AGGREGATE. (HYPOTHETICAL CURVE.)

determining the strength of concrete mixtures which is a distinct advance over anything we have had in the past.

Professor Abrams has also developed a method of evaluating quantitatively the grading of a sand or other aggregate by means of what he has named its "fineness modulus." His experiments have shown that the fineness modulus of a material is related to its concrete-making properties. This fineness modulus is obtained from its sieve analysis and is found by summing the percentages of material remaining on each of the sieves used in the analysis and dividing this sum by 100. Professor Abrams

has standardized on a particular set of sieves, the basic sieve of which is the No. 100 having a sieve opening of 0.0058 in. In each succeeding sieve of this series the opening is double the width of the preceding one. One of the disadvantages of the "fineness modulus" method of determining the effective grading of an aggregate lies in its dependence on a particular series and type of sieve.

Professor Abrams claims that this fineness modulus enables one to interpret properly the sieve analysis of an aggregate and that all aggregates of the same fineness modulus require the same quantity of water to produce a mix of the same plasticity and give concrete of the same strength, provided of course that the aggregate is not too coarse for the quantity of cement used. This is not in conflict with the water-cement ratio theory just described, for the fineness modulus simply reflects the changes in water-cement ratio necessary to produce a given plastic condition.

Working independently on the same general problems, Mr. L. N. Edwards developed experimentally a method of proportioning mortars and concretes by the surface area of their aggregates. Mr. Edwards concluded from his tests that in mortars of the same consistency and made of the same cement and sand the strength obtained is proportional to the relation existing between the cement content and the surface area of the aggregate. He further found that with a given cement and with sands from the same origin the quantity of water required to produce mortars of equal consistency is a function of the water required to reduce the cement to a "normal" paste and the surface area of the particles to be wetted.

In other words, Mr. Edwards claims a relation between strength and surface area and between mobility and surface area, and his tests support his theories so far as mortar mixtures are concerned. Tests since made by the Hydro-Electric Power Commission, under the direction of the speaker, show that these conclusions are under the same conditions equally applicable to concrete mixtures.

Fig. 6 shows the results of a series of tests on mortars by Mr. Edwards which support his claims as to the relation

between strength and surface area, and Fig. 7 a similar curve for concrete obtained from tests in the laboratories of the Hydro-Electric Power Commission.

A corollary of Mr. Edwards's proposition is that if mortars or concretes were proportioned with the same ratio of

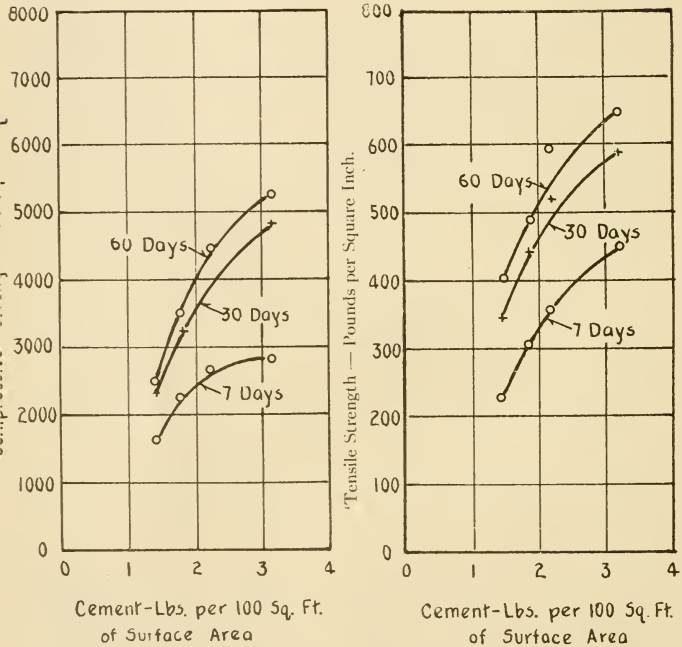


FIG. 6. — RELATION OF STRENGTH OF MORTARS TO VOLUME OF CEMENT IN MIX (EDWARDS, 1918).

cement to surface area of aggregate and mixed to the same consistency or degree of workability, the resulting strength would be equal. This conclusion was supported by a series of tests

(Fig. 8) in which this was found to be so. This, in a general way, has been found to be true of concretes.

Mr. Edwards obtains the surface area of an aggregate by counting and weighing some of each size of grain obtained in its

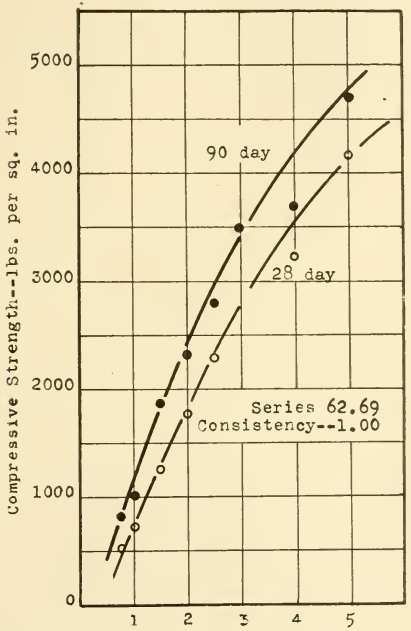


FIG. 7. — RELATION BETWEEN COMPRESSIVE STRENGTH AND VOLUME OF CEMENT IN MIX FOR CONCRETE. (HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.)

sieve analysis, and from this data determining the average number of particles per unit weight for each size. Then, assuming these to be spherical, and knowing their specific gravity, he calculates the average volume per particle, the surface area per

particle, and hence the total surface area per unit weight for each size of separation. This can be done more simply by applying the formula developed by the speaker:

$$A = 236.1 \sqrt[3]{\frac{n}{S^2}}$$

where A equals surface area in square feet per 100 lbs., S equals specific gravity of the sand, and n equals number of grains per gram in any size of separation.

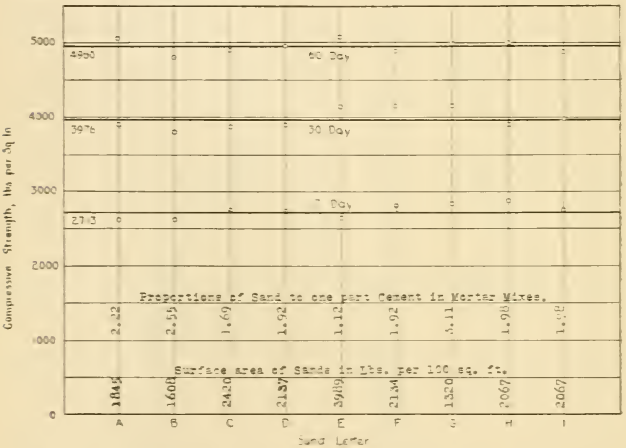


FIG. 8. — COMPRESSIVE STRENGTHS OF 2-IN. MORTAR CYLINDERS PROPORTIONED BY SURFACE AREAS (EDWARDS).

The surface area of any mixed material can be found by multiplying the surface area per unit weight of each size of separation by the weight of that size present in the material, and adding these. The value thus obtained is not the true surface area, for the latter cannot be obtained, as the particles are not true spheres, are variable in shape, and have not smooth surfaces. However, this value undoubtedly bears a constant relation to the true surface area and for all practical purposes is equally as useful.

Mr. Edwards's tests emphasize the relation between strength and surface area but recognize the effect of water by stating that this relationship holds only for concretes of the same consistency. He found it possible to maintain mortars of uniform consistency by proportioning the water in them by a formula involving the surface area of the aggregates used. In other words, to obtain mortar mixtures of equal consistency and strength it was necessary to proportion both the cement and water by surface area.

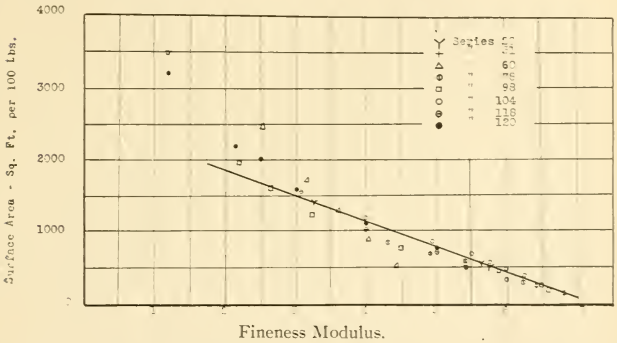


FIG. 9. — RELATION BETWEEN FINENESS MODULUS AND SURFACE AREA OF AGGREGATE. (DERIVED FROM ABRAMS' DATA.

Mr. Edwards is therefore using surface area as a means of evaluating the grading of an aggregate in much the same way as Professor Abrams uses fineness modulus. Both are used to determine the proper proportions for concrete of a desired strength and having a given degree of workability. Both use a formula involving these to determine the proper amount of water to obtain this degree of workability. It would be reasonable to expect, therefore, that the surface area and fineness modulus would be related in some way. It may be said that this is both the fact and not the fact. There is no mathematical relationship between fineness modulus and surface area, although both their formulæ involve a function of the diameter of the

particles of aggregate. If, however, the surface area and fineness modulus of a number of graded concrete aggregates are calculated and plotted it will be found that the relation between the two can be approximated by a straight line. Fig. 9, which

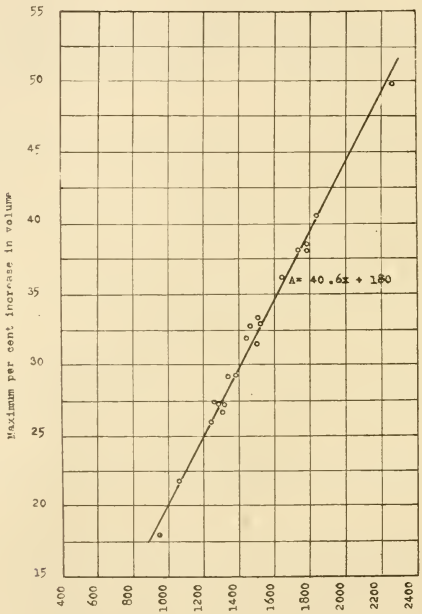


FIG. 10. — RELATION BETWEEN SURFACE AREA AND MAXIMUM BULKING FOR GRADED SANDS.

is derived from the published results of Professor Abrams' experiments, illustrates this. The aggregates included were sands and mixed sands and gravels of widely different gradings.

It is therefore not correct to say that surface area varies as the fineness modulus, but that it varies similarly to the fineness

modulus; and this holds true only with graded aggregates. It is true, as has been stated, that for any one value of fineness modulus there can be an infinite number of values of surface area, or vice versa, but it is equally true that for the average

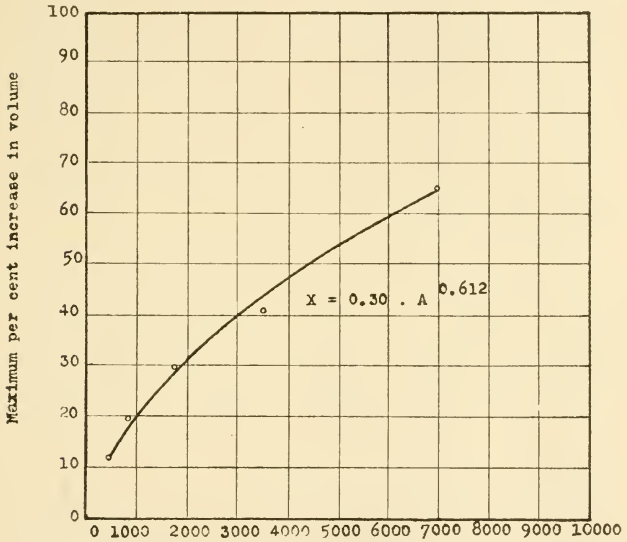


FIG. 11. — RELATION BETWEEN SURFACE AREA AND MAXIMUM BULKING FOR SANDS OF ONE SIZE.

graded aggregate the range of values of fineness modulus for any one value of surface area falls within narrow limits.

Surface area and fineness modulus are but two different ways of evaluating the same property of an aggregate. Both depend on the grading of the aggregate. Fineness modulus depends also on the particular series and type of sieve used in determining the mechanical analysis of the aggregate, while surface area is entirely independent of the sieves used in its

determination. Fineness modulus is therefore the empirical method: surface area, the scientific.

Other properties have been found to be related to the surface area of an aggregate. Consider the effect of moisture on the volume of fine aggregates. As is familiar to all, sand ordinarily occupies more space moist than when dry. It "bulks" due to the moisture contained. That these changes in volume were related to the surface area of the aggregates involved was not known until recently. Figs. 10 and 11 show the relations obtained for graded materials and for materials in which all the particles were approximately of one size. The form of these curves is typical, but the equations expressing the relationships are not general and only hold for the particular methods of test used in this investigation.

Both the relation between water-cement ratio and strength and between surface area, strength and consistency, have been referred to as theories. It is hardly correct to call either "theories" if the word "theory" be used in its strictly scientific sense. The relation between water-cement ratio and strength is influenced by consistency, gradation and proportions in a manner as yet only partially understood. Surface area, likewise, is subject to very definite limitations of which as yet equally little is known. A great deal of investigation remains to be done before either are thoroughly understood.

The proper theory of mixture has yet to be developed. If the speaker may be allowed to predict, he would prophesy that future work will show that this theory will include reference to voids either directly or indirectly, that it will include a function dependent on some property of the aggregated particle such as surface area which can be obtained by a direct test on the aggregates instead of from a mechanical analysis, and that it will involve water-cement ratio only as a secondary function and not as a primary function, as it is now considered.

Methods of proportioning based on the foregoing studies have been developed by Professor Abrams, Mr. Edwards and the speaker. They have much in common. Each is a method of designing concrete mixtures to give specified compressive strengths after certain periods of time. Each has distinct

limitations. None offers a panacea for the ills of concrete; the fundamentals of good concrete practice must still be observed. All offer an improvement over the methods of proportioning now in common use.

The method of Professor Abrams is based on his water-cement ratio strength relation and his fineness modulus method of evaluating aggregates. The method is based on the assumption that provided the concretes are plastic and the aggregate is not too coarse for the quantity of cement used, a given compressive strength is always equivalent to the same water-cement ratio. No other limitations are placed on the grading of the aggregate or on the consistency or proportions of the mix.

The method requires a knowledge of the compressive strength of the concrete being proportioned, the class of work for which it is intended, and the consistency of the concrete, mechanical analyses and character of the materials which are to be used in its manufacture.

Knowing the compressive strength, the water-cement ratio equivalent to it is obtained from Fig. 1. Reference is next had to a table of maximum permissible values of fineness modulus for different sizes of aggregate and different proportions, Table I.

TABLE I.

MAXIMUM PERMISSIBLE VALUES OF FINENESS MODULUS OF AGGREGATES.

For *mixes* other than those given in the table, use the values for the next leaner mix.

For *maximum sizes* of aggregate other than those given in the table, use the values for the next smaller size.

Fine aggregate includes all material finer than No. 4 sieve; *coarse aggregate* includes all material coarser than the No. 4 sieve. *Mortar* is a mixture of cement, water and fine aggregate.

This table is based on the requirements for *sand-and-pebble* or *gravel* aggregate composed of approximately spherical particles, in ordinary uses of concrete in reinforced concrete structures. For other materials and in other classes of work, the maximum permissible values of fineness modulus for an aggregate of a given size is subject to the following corrections:

(1) If *crushed stone* or *slag* is used as coarse aggregate, *reduce* values in table by 0.25. For crushed material consisting of unusually flat or elongated particles, *reduce* values by 0.40.

(2) For *pebbles* consisting of *flat particles*, *reduce* values by 0.25.

(3) If *stone screenings* are used as fine aggregate, *reduce* values by 0.25.

(4) For the top course in *concrete roads*, *reduce* the values by 0.25. If finishing is done by *mechanical means*, this reduction need not be made.

(5) In work of *massive proportions*, such that the smallest dimension is larger than 10 times the maximum size of the coarse aggregate, *additions may be made* to the values in the table as follows: for $\frac{3}{4}$-in. aggregate, 0.10; for $1\frac{1}{2}$-in., 0.20; for 3-in., 0.30; for 6-in., 0.40.

Sand with fineness modulus lower than 1.50 is undesirable as a fine aggregate in ordinary concrete mixes. Natural sands of such fineness are seldom found.

Sand or screenings used for fine aggregate in concrete must not have a higher fineness modulus than that permitted for mortars of the same mix. Mortar mixes are covered by the table and by (3) above.

Crushed stone mixed with both finer sand and coarser pebbles requires no reduction in fineness modulus provided the quantity of crushed stone is less than 30% of the total volume of the aggregate.

Mix Cem.-Agg.	Size of Aggregate													
	0-28	0-14	0-8	0-4	0-3*	0-$\frac{3}{8}$	0-$\frac{1}{2}$*	0-$\frac{3}{4}$	0-1″*	0-1$\frac{1}{2}$	0-2.1*	0-3″	0-4$\frac{1}{2}$*	0-6″
1-12	1.20	1.80	2.40	2.95	3.35	3.80	4.20	4.60	5.00	5.35	5.75	6.20	6.60	7.00
1-9	1.30	1.85	2.45	3.05	3.45	3.85	4.25	4.65	5.00	5.40	5.80	6.25	6.65	7.05
1-7	1.40	1.95	2.55	3.20	3.55	3.95	4.35	4.75	5.15	5.55	5.95	6.40	6.80	7.20
1-6	1.50	2.05	2.65	3.30	3.65	4.05	4.45	4.85	5.25	5.65	6.05	6.50	6.90	7.30
1-5	1.60	2.15	2.75	3.45	3.80	4.20	4.60	5.00	5.40	5.80	6.20	6.60	7.00	7.45
1-4	1.70	2.30	2.90	3.60	4.00	4.40	4.80	5.20	5.60	6.00	6.40	6.85	7.25	7.65
1-3	1.85	2.50	3.10	3.90	4.30	4.70	5.10	5.50	5.90	6.30	6.70	7.15	7.55	8.00
1-2	2.00	2.70	3.40	4.20	4.60	5.05	5.45	5.90	6.30	6.70	7.10	7.55	7.95	8.40
1-1	2.25	3.00	3.80	4.75	5.25	5.60	6.05	6.50	6.90	7.35	7.75	8.20	8.65	9.10

* Considered as "half-size" sieves; not used in computing fineness modulus.

At this point it is necessary either to assume the mix or the proportions in which the fine and coarse aggregate will be combined. The latter procedure is the simpler. If this is done, the fineness modulus of the combined fine and coarse aggregate can be calculated and, from the table referred to, the leanest permissible mix obtained. A formula is then used to determine the proper quantity of water at the required consistency for this mix and materials of the assumed fineness modulus. If this quantity of water does not give the proper water-cement ratio, the mix or

the proportions of fine and coarse aggregate or both must be adjusted until the desired water-cement ratio results.

Professor Abrams has simplified this procedure by developing the nomographic chart, Fig. 12, which includes the four variables, fineness modulus, mix, consistency and strength. This elimi-

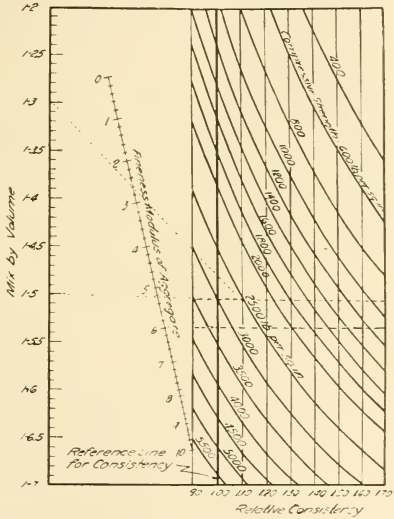


FIG. 12. — DIAGRAM FOR THE DESIGN OF CONCRETE MIXTURES (ABRAMS).

nates the calculation of water content and water-cement ratio of the mix and permits the immediate determination of the proper proportions for any consistency and fineness modulus.

Professor Abrams defines the plastic conditions of concrete by a system of relative consistency. Normal or a relative consistency of 1.00 is of such plasticity that a 6 x 12 in. cylinder of concrete will slump $\frac{1}{2}$ to 1 in. after removal of the metal form by a steady upward pull immediately after molding the specimen. A relative consistency of 1.10 is a concrete mixture having 10 per cent. more water than the same mixture at normal con-

sistency, and is of course increasingly plastic. A relative consistency of 1.10 represents about the driest concrete which can be used in concrete road work, a relative consistency of 1.25 about the wettest concrete which should be used in reinforced concrete building construction.

Mr. Edwards's method is based entirely on surface area. To apply it, it is necessary to know the surface area of the materials to be used and the relation between surface area and cement for concrete of the compressive strength desired. Mr. Edwards does not recognize water-cement ratio or propose an equivalent of Abrams's system of relative consistencies.

The surface area of an aggregate is obtained from its mechanical analysis by the method already outlined. Grain counts of the different materials are not necessary since the data of Edwards's is offered by him as applying to all ordinary materials. Charts and tables are used to simplify this work.

At the present time the relation between surface area and cement for the materials under consideration must be found experimentally for each case. Further investigation may show this relationship so nearly constant that, with a few modifications, one set of values may be found to fit all materials.

In applying the method, the surface area per unit of weight or volume is found for the aggregates, both fine and coarse, from their mechanical analysis and a table or chart of surface areas. A decision must then be made as to the proper combination of the fine and coarse aggregates for the work in hand. This can be had by a study of their mechanical analysis curves, or can simply be set arbitrarily by experience. The cement requirement for a unit volume of mixed aggregate or for an entire batch of concrete can then be obtained by multiplying the surface area of each material in the unit volume or batch by the cement per unit of surface area required for the quality of concrete sought.

In this method no definite provision is made for proportioning mixtures of different consistencies or warning given that the relations established hold only for one consistency. Mr. Edwards in his tests on mortars gaged his mixtures to one degree of plasticity and thus provided a condition fundamental to the success of his method.

A comparison of the two methods is interesting. Edwards does not recognize water-cement ratio, but to obtain concretes of equal strength he proportioned both cement and water by surface area so that their relationship is constant, and mixtures of equal water-cement ratio result. Surface area is in effect the same as fineness modulus and is used for the same purpose in much the same way. Thus fundamentally the two methods are similar.

The method of Abrams has been very fully developed and is offered as applicable to any materials and for concrete mixtures of all workable consistencies. The method of Edwards is equally applicable to all materials and consistencies, but lacks the data essential for its immediate application without special tests for each new set of aggregates encountered. There is little doubt, were studies carried out to obtain this essential information, the surface area method would do anything that the fineness modulus method will do, and do it equally well.

If the speaker were to criticize the fineness modulus method, it would be because it attempts to apply to all materials and conditions without modification. The discussion of the vagaries of the water-cement-ratio-strength relation earlier in this paper shows how unsafe it would be to apply any method based on the assumption that this relation is constant to any and all conditions of practice without checking the results experimentally.

The method of proportioning developed by the Hydro-Electric Power Commission of Ontario was brought about by their adoption of the principle of specifying concrete according to quality instead of by arbitrary proportions. This necessitated the study of a means of obtaining concrete of the desired quality under a variety of conditions. This work was undertaken by the laboratories of the Commission, under the direction of the speaker.

A study was made of both the fineness modulus and surface area methods of proportioning. Neither was considered entirely satisfactory, and after considerable experimental work a method was developed which in many particulars is a compromise between the two older methods.

No attempt has been made by the Commission to develop

a method which could be applied anywhere without experimental study of the materials with which it is to be used. The method is not general in this respect but is general in the sense that it can be applied to any materials after their concrete-making properties are once determined.

An analysis of the problem showed two fundamental requirements. The concrete must have a strength at least equal to that fixed by the design of the structure of which it forms a part and during construction it must be sufficiently plastic to handle and place properly.

A means of fulfilling the first condition was found in the relation between water-cement ratio and compressive strength. Without accepting the claim that the water-cement ratio of a mixture absolutely decides its strength, reference to the curves of Figs. 2, 3, 4 and 5 shows that under certain conditions the variation in strength for any one water-cement ratio is very much less than under other conditions and that the conditions under which the variations are a minimum are those which can be provided for by proper supervision and inspection.

The most important of these conditions is a minimum variation in consistency. In designing a concrete mixture which will meet a given water-cement ratio requirement it is necessary to have some method of determining the quantity of water which must be used to obtain a desired workability. This can be done by means of surface area, taking advantage of the fact that the water required to obtain mixtures of constant mobility is a function of the surface area of the aggregate used.

The method of proportioning developed consists, in brief, of obtaining experimentally for each class of concrete and for the concrete materials in hand the relation between water-cement ratio and strength and between cement content and surface area for one degree of plasticity known as "normal consistency." If normal consistency is satisfactory for the particular work in hand, the cement content and water-cement ratio corresponding to the quality of concrete specified are taken from the tests, and the mixtures proportioned accordingly. If the normal consistency is not satisfactory, the consistency is varied as necessary by changing both the cement and water proportionately — thus

obtaining the proper water-cement ratio — until the desired workability is obtained.

The experimental investigation consists of a series of tests on concretes made of the materials to be used on the work in question, the cement content of which is proportioned on the basis of surface area and the mixtures of which are all of the same consistency. Usually the information is obtained from a set of thirty-five test cylinders made up in seven different proportions according to the best laboratory practice and tested when twenty-eight days old. Such a series can be made at small cost.

Table II is an example of the results obtained from one of these series. This information is plotted as in Fig. 13 (*a*) and (*b*). From these curves is obtained the information required in calculating the proportions. (Table III.)

TABLE II.

EXAMPLE OF TESTS USED TO ESTABLISH RELATION BETWEEN CEMENT CONTENT, WATER-CEMENT RATIO AND COMPRESSIVE STRENGTH.

Series 62-69 — Niagara Power Development.

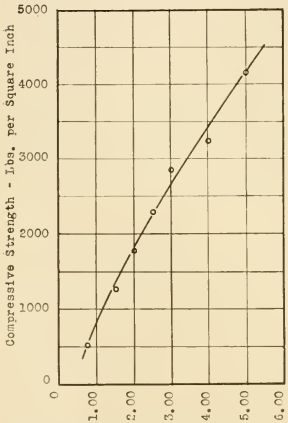
Cement — lbs. per 100 sq. ft.	0	.75	1.5	2.0	2.5	3.0	4.0	5.0
Water-cement ratio by weight		1.426	0.843	0.654	0.557	0.498	0.423	0.326
Compressive strength, lbs. per sq. in. (28 days)		519	1 393	1 919	2 262	2 890	3 655	3 686
		441	1 374	2 027	1 980	2 714	2 873	4 310
		487	1 070	1 740	2 462	2 749	3 450	4 380
		617	1 201	1 514	2 347	3 010	2 960	4 623
		...	....	1 636	2 403	2 892	....	3 792
Average		516	1 260	1 767	2 291	2 851	3 235	4 158

TABLE III.

EXAMPLE OF CONSTANTS USED FOR PROPORTIONING MIXTURES OF NORMAL CONSISTENCY FOR DIFFERENT CLASSES OF CONCRETE.

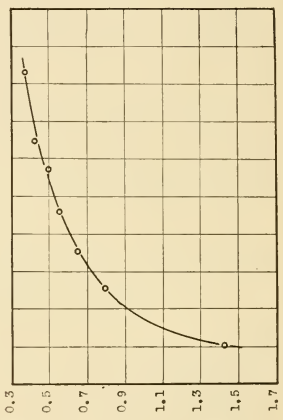
Class.	Minimum Specified Compressive Strength. Lbs. per Sq. In.	Cement — Lbs. per 100 Sq. Ft. Surface Area Normal Consistency.	Range of Water-Cement Ratio by Weight. Min.	Max.
A.	2 500	1.45	0.48	0.53
B.	2 000	2.00	0.56	0.62
C.	1 500	2.50	0.65	0.73
D.	1 000	3.15	0.80	0.92

It will be noticed that water-cement ratio as used by the Commission is the ration of weight of water to weight of cement. As originally proposed, it was the ratio of volume of water to volume of cement. It was found more convenient to have the ratio on a weight basis, and the change was accordingly made, and this practice is now standard with the Commission.



Cement Content, Lbs. per 100 Sq. Ft. of Surface Area.

FIG. 13 (*a*).



Water Content Ratio by Weight

FIG. 13 (*b*).

CURVES, ESTABLISHING RELATION BETWEEN COMPRESSIVE STRENGTH, WATER-CEMENT RATIO AND CEMENT CONTENT AT NORMAL CONSISTENCY.

In Fig. 13 (*a*) is given the relation between cement content and compressive strength at normal consistency, from which can be read the cement requirement at that consistency corresponding to any desired strength. It is customary to allow a margin of several hundred pounds over the minimum requirements of the specification to care for field conditions: the better the inspection and workmanship, the smaller the margin thus necessary.

From Fig. 13 (*b*) can be found the water-cement ratio corresponding to the same strength. The cement content multiplied

by this water-cement ratio will give the quantity of water per unit of area which must be used for concrete of the corresponding strength.

All that now remains to be done is to multiply this cement and water content per unit of area by the total surface area of the aggregates to be used in a batch of concrete, putting the results in terms of bags of cement and gallons of water.

The water content of the batch thus determined is the maximum quantity of water which can be present in the mixtures used if concrete of the specified quality is to be obtained. Since in actual work the aggregates already contain an appreciable quantity of water, this must be determined and deducted from the total water before the net amount to be added at the mixer is known. This information is obtained as necessary by determining the moisture contents of the aggregates in the condition used. This test is usually confined to the fine aggregates, as the moisture contained in the average coarse aggregate is of such small amount as to be negligible.

The proper ratio of fine to coarse aggregate is determined from the results of the mechanical analyses of these materials, the effort being made to use as high a percentage of coarse material as possible and still maintain a workable mixture. This varies with the richness of the mix, grading of the sand, consistency, character of the materials, methods of placing and class of work. It must be arrived at, first, by judgment based on past performances, and settled finally by adjustment in the field. In the experimental work which forms the basis of this method of proportioning, a mixture of fine and coarse aggregate is used which will give concretes workable in small masses. This is usually a mixture of 2 parts fine aggregate to 3 parts coarse. The results obtained from such tests have been found to apply satisfactorily to the less sanded field mixtures.

It will be seen that while this method is general in its application, its use in any particular instance requires experimental information on the materials to be employed. In the case of small jobs, the cost of the investigations may be burdensome, but on jobs of a thousand cubic yards or more its cost is but a few cents a yard. The method requires skill in its application,

but so too does that of Abrams and Edwards. In their present development none of these methods can safely be used except by men who appreciate their limitations.

This method, while employing the unsatisfactory water-cement ratio strength relation, uses it in such a way as to minimize its shortcomings. The tests are made using a workable consistency with materials graded and combined closely as they will be actually used. In this way the variations in strength for any one value of water-cement ratio are reduced to a minimum.

This method will be applicable to the smaller jobs when more experience has been gained in its use, so that the proper constants for different aggregates, for different gradings and for different cements can be determined with fair accuracy from mortar tests. This phase of the problem is being studied now, and there is every promise that some inexpensive test will be developed for this purpose.

The Commission has used this method on three jobs. It was first applied in the construction of a small dam and power house at High Falls, Ontario, in the summer of 1919. Experience gained there led to the decision to use it on a larger job, and during last summer and fall some 36 000 cu. yds. of concrete were proportioned thereby on a power development under construction on the Nipigon River, north of Lake Superior. Because of the results obtained there it was decided to apply it on still larger work, and in the next twelve months this method will be used to proportion nearly 600 000 cu. yds. of concrete of all classes on three different jobs now under construction by the Commission.

At High Falls approximately 60 sets of test cylinders were made from concrete taken directly from the forms. These were stored in moist sand for two weeks, then packed in damp sawdust and shipped to the Commission's laboratories at Toronto for test. More test specimens were taken on this job than its size warranted because the method was new and under close observation and because the daily yardages poured were small. Table IV contains the results of the tests on these specimens.

The materials used at High Falls were unscreened gravel

graded up to one inch and crushed rock screened free from dust. The quantities in Table IV are stated in terms of these materials, which accounts for the odd proportions used.

The results obtained during September, October and November were very satisfactory. The ultimate strengths obtained

TABLE IV.

Representative Results of Field Tests of Concrete, High Falls Power Development, Hydro-Electric Power Commission of Ontario.

Class A.

Minimum Compressive Strength, 2 500 lbs. per sq. in.
Maximum Water-Cement Ratio, 0.57.

Date.	Proportions.	Water-Cement Ratio by Weight.	Compressive Strength at 28 Days. Lbs. per Sq.In.
Sept. 16	1–3.3–3.4	0.45	3 338
Sept. 17	do.	0.43	3 730
Sept. 18	do.	0.43	4 060*
Sept. 19	1–3.0–3.2	0.43	3 965*
Sept. 19	1–3.0–3.4	0.43	3 775*
Sept. 19	1–3.3–3.5	0.47	2 780*
Sept. 20	do.	0.44	2 993*
Sept. 22	do.	0.45	3 450
Oct. 3	do.	...	3 475
Nov. 11	1–3.0–3.4	0.52	2 920
Nov. 12	do.	0.52	3 356
Nov. 14	do.	0.52	2 175
Nov. 15	do.	0.52	1 950*
Nov. 20	do.	0.52	3 185
Nov. 29	1–3.0–3.2	0.51	3 445
1920.			
Jan. 29	1–2.7–2.2	0.56	2 019
Jan. 29	1–2.5–3.0	0.52	2 498
Feb. 6	1–2.5–2.0	0.52	1 742
Feb. 10	1–2.6–2.0	0.54	2 190
Feb. 11	1–3.0–2.4	0.57	1 966
Feb. 12	do.	0.57	2 280†
Feb. 17	1–2.6–2.0	0.52	2 470†
Feb. 18	do.	0.52	2.380†
Mar. 26	1–2.6–1.4	0.52	2 380*

Except where noted, results are average of tests on two specimens.

* Test on single specimen.
† Average of tests on three specimens.

Class B.

Minimum Compressive Strength, 2 000 lbs. per sq. in.
Maximum Water-Cement Ratio, 0.64.

Date.	Proportions.	Water-Cement Ratio by Weight.	Compressive Strength at 28 Days. Lbs. per Sq. In.
Oct. 8	1–3.6–3.8	0.64	2 100
Oct. 10	do.	0.64	1 785†
Oct. 11	1–3.6–4.7	0.64	1 815*
Oct. 16	1–3.6–3.8	0.64	1 963
Oct. 17	do.	0.64	2 447
Oct. 18	do.	0.64	2 785
Nov. 27	do.	0.59	3 360
Dec. 2	do.	0.59	1 856
Dec. 3	do.	0.59	1 825
Dec. 4	do.	0.59	2 034
Dec. 11	do.	0.59	1 943
Dec. 13	do.	0.59	1 868
Dec. 21	do.	0.59	1 820
Dec. 23	do.	0.59	2 100
1920.			
Jan. 1	do.	0.64	1 594*
Jan. 5	do.	0.63	958
Jan. 9	1–3.3–3.5	0.64	1 068
Jan. 9	1–3.6–3.8	0.62	613
Jan. 14	1–3.6–2.9	0.62	1 132
Feb. 5	1–3.4–3.6	0.62	1 530
Apr. 3	1–3.9–2.8	0.59	1 750
Apr. 3	1–3.6	0.59	1 902†
Apr. 4	1–3.0–1.6	0.59	2 867†

Except where noted, results are average of tests on two specimens.

* Test on single specimen.
† Average of tests on three specimens.

Class C.

Minimum Compressive Strength, 1 500 lbs. per sq. in.
Maximum Water-Cement Ratio, 0.74.

Date.	Proportions.	Water-Cement Ratio by Weight.	Compressive Strength. Lbs. per Sq. In.
1920.			
Feb. 20	1–4.5–2.4	0.74	1 068†
Feb. 23	do.	0.74	1 778†
Feb. 23	1–4.3–3.2	0.76	1 335*
Feb. 23	1–4.5–3.6	0.74	2 025*
Feb. 25	1–4.5–2.4	0.74	1 175
Feb. 25	1–4.0–2.1	0.74	1 237
Feb. 27	1–2.0–3.9	0.74	1 726
Mar. 1	1–3.9–3.0	0.74	1 713†
Mar. 4	do.	0.74	1 671†
Mar. 8	1–3.6–1.9	0.74	1 431†
Mar. 10	1–3.9–2.0	0.74	1 732*
Mar. 11	do.	0.74	1 493†
Mar. 24	do.	0.74	1 437
Apr. 22	do.	0.74	2 190
Apr. 22	1–3.9–2.8	0.74	1 505‡

Except where noted, results are average of tests on two specimens.

* Test on single specimen.
† Average of tests on three specimens.
‡ Average of tests on four specimens.

during these months are considerably in excess of the minimum required, but this was due mainly to the use of a drier consistency than the proportions were designed for. It was considered inadvisable to take advantage of this and use leaner proportions, because of our inexperience with the method.

After cold weather set in, a change was noticed in the test results, which began to drop below the expected values. The reason was sought, and the trouble was found to be in the samples. It was difficult to maintain their storage at proper temperature in the temporary buildings used for this purpose. It was impossible to protect them from the cold in their long journey to Toronto. The result was that setting was retarded an indeterminate amount with consequent decrease in strength.

Experience at High Falls lead to the recommendation that a field laboratory be installed at Nipigon, and that a specialist

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in concrete be used on this work for the inspection of materials and the supervision of the processes of concreting.

A small laboratory was installed and was equipped with an inexpensive 100-ton hydraulic-type testing machine, sieves for the analysis of sand and stone, and miscellaneous apparatus for determining their weight per cubic foot, moisture content, cleanliness and freedom from organic impurities. A small building was erected to house the apparatus and for the storage of the concrete test specimens.

An experienced concrete engineer from the Toronto Laboratories was assigned to the staff of the resident engineer. His duties covered supervision of the laboratory and inspection of both materials and operations.

Inspection on this job was very thorough. The materials were not only tested but a watch was kept on the sand and gravel pits, washing plant, crusher and stock piles. The inspection of concreting included all details in connection with proportioning, mixing and placing. An effort was made to see that materials were accurately measured, that the batches were properly mixed and that the chuting plant was arranged so as not to interfere with the quality of the concrete delivered. Inspection was also maintained on the placing of concrete, spadding, laitance and removal of forms.

The same system of taking and curing test specimens was followed here as at High Falls. Eighty sets of 8 x 16 in. cylinders, representing 36 000 cu. yds., were made. One cylinder was broken at seven days, the other two at twenty-eight days. The seven-day tests were only possible because of the laboratory facilities provided at hand. They were chiefly valuable as indicative of quality and were of little use in determining the probable strength at the later age.

Conditions at Nipigon made it more difficult to maintain the quality of the concrete there than at High Falls. Due to the cement situation last summer it was necessary to obtain supplies from six different mills. Sand was obtained from two different sources, a gravel pit and a sand pit. The pit sand was fine and micaceous and required more cement than a better graded sand. The gravel screenings were dirty and required

washing. When available it was mixed with the pit sand to improve the grading of the latter. The variations in the materials were great, were difficult to anticipate and compensate for, and added materially to the problem of proportioning the mixtures accurately.

The tests made to date at Nipigon have been tabulated in Table V. For the first five months the results obtained were better than at High Falls. During the last two months, October and November, they were less satisfactory. The cooler weather may have been in part to blame for this, but only in part, as the samples were protected as far as possible from low temperatures. The work was a rush job, and toward the last the concreting was pushed to the utmost with consequent loss in efficiency, making inspection more difficult. The result was inevitable, — the quality of the concrete suffered.

Concrete is now being placed on the Niagara Power Development of the Commission under the same method. A complete field laboratory is being installed, as at Nipigon; a concrete engineer has been assigned to the supervision of the inspection and testing of the concrete. This will be very thorough and will necessitate a large organization. Five hundred thousand cubic yards of concrete of all classes is to be placed on this job in the next twelve months. Some has already been placed and the results obtained to date have been very satisfactory.

At High Falls about 70 per cent. of the sets averaged better than 200 lbs. per sq. in. under the design strength. At Nipigon, if all the tests are included, 60 per cent. come in this class. If the results of the last two months, which are not a fair indication of what can be done under normal conditions, are included, approximately 80 per cent. are in this category. At Niagara Falls somewhat better results are being obtained.

In general we are well satisfied with this method of proportioning. While one hundred per cent. control has not been obtained, our experience has indicated the paths that lead toward this goal. The method will design concrete mixtures of given strength and consistency, but present practice in measuring materials before mixing allow such variations in the sand and stone content of a batch that any attempt to be precise in determining the proper proportions are rendered abortive thereby.

TABLE V.

REPRESENTATIVE RESULTS OF FIELD TESTS OF CONCRETE, NIPIGON POWER DEVELOPMENT, HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

Class A.

Minimum Compressive Strength, 2 500 lbs. per sq. in.
Maximum Water-Cement Ratio, 0.60.

Date.	Proportions.	Water-Cement Ratio. Weight.	Ultimate Strength at 28 Days. Lbs. per Sq. In. 7-Day.	28-Day.
June 5	1–2.5–3.0	0.54	....	2 330†
June 6	1–1.8–3.2	0.55	....	2 660†
June 11	1–1.7–3.2	0.54	....	3 360
June 16	1–1.8–3.2	0.54	2 360	3 415
June 27	1–2.0–4.0	0.57	2 190	3 288
June 30	1–2.0–3.9	0.57	2 740	3 238
July 7	1–2.1–3.4	0.57	2 181	3 050
Aug. 3	1–2.2–3.7	0.56	1 509	2 982
Aug. 5	do.	0.56	2 281	2 902
Aug. 11	1–2.7–4.0	0.60	2 790	2 820
Aug. 14	1–3.0–5.5	0.61	1 990	2 821
Aug. 19	1–2.3–3.7	0.59	1 125	3 505
Aug. 20	do.	0.58	1 535	2 225
Sept. 2	1–2.2–3.8	0.57	1 221*	2 525‡
Sept. 4	do.	0.57	1 194	2 352
Sept. 8	do.	0.59	1 235	2 396
Sept. 9	do.	0.59	1 390	2 625
Sept. 13	do.	0.58	1 203*	2 468‡
Sept. 15	do.	0.58	1 280	2 465
Sept. 16	do.	0.58	1 115	2 085
Sept. 21	1–2.2–3.9	0.60	634	2 535
Sept. 24	do.	0.60	927*	2 425‡
Sept. 27	do.	0.60	905	1 745
Sept. 30	do.	0.60	1 173*	2 363‡
Oct. 1	do.	0.60	871	1 826
Oct. 2	do.	0.60	630	1 343
Oct. 5	1–1.6–2.9	0.57	951	2 240
Oct. 19	1–1.9–5.4	0.54	1 371*	2 271‡
Oct. 27	do.	0.55	792	1 470
Oct. 31	1–2.2–4.0	0.58	835	1 290
Nov. 2	1–1.9–3.4	0.56	1 275	1 762
Nov. 3	do.	0.56	1 268	2 217
Nov. 7	do.	0.58	916	1 141
Nov. 8	do.	0.60	951	1 232
Nov. 9	do.	0.56	795	1 256
Nov. 15	do.	0.56	986	1 602

Except where noted, 7-day results are single test specimens; 28-day results are average of two test specimens.

* Average of tests on two specimens. † Average of tests on three specimens.
‡ Average of tests on four specimens.

Class B.

Minimum Compressive Strength, 2 000 lbs. per sq. in.
Maximum Water-Cement Ratio, 0.68.

Date.	Proportions.	Water-Cement Ratio. Weight.	Ultimate Strength at 28 Days. Lbs. per Sq. In. 7-Day.	28-Day.
May 24	1–2.5–4.5	0.60	....	2 535†
May 28	do.	0.60	....	2 560†
May 30	1–2.0–3.1	0.55	....	2 460†
June 2	do.	0.55	....	2 430†
June 9	1–2.5–3.7	0.60	....	2 110§
June 11	1–2.3–3.8	0.60	1 314	2 270
June 15	1–2.3–3.3	0.60	1 512	2 937
June 20	do.	0.60	961	2 032
Aug. 17	1–2.6–4.6	0.64	1 395	2 605
Aug. 26	do.	0.68	755	2 180
Aug. 28	do.	0.67	835	1 365
Sept. 18	do.	0.64	1 354	2 060
Sept. 25	1–2.2–3.9	0.64	1 030	1 683
Oct. 3	1–2.6–4.6	0.68	1 025	1 817
Oct. 5	1–2.3–3.8	0.66	1 103	2 220
Oct. 8	do.	0.66	712	2 297
Oct. 9	do.	0.66	631	1 640
Oct. 14	1–2.6–4.6	0.67	494	1 379
Nov. 11	1–2.2–4.0	0.66	710	1 397

Except where noted, 7-day results are single test specimens; 28-day results are average of two test specimens.

† Average of tests on three specimens.
§ Test on single specimen.

Class C.

Minimum Compressive Strength, 1 500 lbs. per sq. in.
Maximum Water-Cement Ratio, 0.81.

Date.	Proportions.	Water-Cement Ratio. Weight.	Ultimate Strength at 28 Days. Lbs. per Sq. In. 7-Day.	28-Day.
May 13	1–2.3–4	0.56	....	1 640†
June 4	1–2.5–4.5	0.72	....	1 835†
June 14	1–3.0–5.0	0.72	1 300	2 125
June 29	do.	0.80	1 310	2 090
July 7	1–3.2–4.5	0.80	1 110	2 592
July 17	1–3.0–5.4	0.80	395	1 430
July 20	1–3.3–5.5	0.80	1 680	1 927
July 30	do.	0.75	1 062	1 630
Aug. 7	do.	0.79	1 180	2 335
Aug. 10	1–2.9–5.0	0.77	1 390	2 062
Aug. 12	1–3.3–5.5	0.77	1 260	2 752
Aug. 13	1–2.6–5.5	0.71	1 180	2 125
Aug. 22	1–3.3–5.5	0.80	1 100	2 022
Aug. 24	do.	0.80	398	1 437
Oct. 11	1–2.6–4.6	0.77	807	1 895

Except where noted, 7-day results are single test specimens; 28-day results are average of two test specimens.

† Average of tests on three specimens.

Probably few realize the inaccuracies of our present volumetric methods of measuring aggregates. A 2 per cent. change in moisture content of a sand may cause a 15 per cent. difference in the actual quantity per unit volume. In the average measuring hopper a 1-in. variation in the measurement of the fine aggregate will make a 10 per cent. difference in the volume in a batch.

Our experience has shown that most of the trouble with consistency — the occasional dry and wet batches — are directly traceable to variations in measurement. These variations are in turn the cause of much low-testing concrete because of the tendency for the workman after a dry batch or batches to increase the quantity of water in the mix. The most careful and continuous inspection will not prevent this, and even if the accidental variations of measurement were eliminated, those due to moisture changes are alone sufficient to cause appreciable errors.

Probably the greatest single improvement that can be made in our best concrete practice, which it is assumed does not permit the use of excess water and recognizes the need of proper inspection, is not the use of any new method of proportioning but the use of weight measurement of aggregates — particularly sand — in place of the present system of measuring aggregates by volume. This may seem a radical statement but the experience of the Commission fully justified it.

The idea that concrete is a material that can be made by anybody is one of the most pernicious errors existing among engineers. Our method of proportioning is only one part of our system of insuring good concrete, which begins with preliminary investigations of available aggregates, includes studies of their concrete-making properties, continues during construction in rigid inspection and testing of all materials and of every step through which these materials pass before their final deposition in the finished structure, and ends only when the forms are removed and the concrete is ready for service.

The best inspection can only be had by employing men who are conversant with both the theoretical and practical phases of their work. With concrete becoming of such importance and of such wide application, there is no excuse for employing men of less ability, and the additional cost of their service will be offset by the economies they are able to effect and the quality of the work obtained.

Many will question the economy of going to the refinements here recommended except on the very largest jobs. We question their position. The advantages of uniform concrete are obvious. If concrete of uniform quality can be continuously guaranteed by the maker, the present high factors of safety can be reduced. Either less concrete will then be required or concrete of a lower grade can be used. In addition, economies due to the use of less cement for given results are possible under close control. On any but the smallest jobs the advantages obtained will justify the cost.

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6. Example of the Application of Abrams' Water Ratio to Proportioning Concrete. Stanton Walker. American Concrete Institute, Vol. XVI, 1920.

7. The Volume-Moisture Relation in Sand and a Method of Determining Surface Area Based Thereon. R. B. Young and W. D. Walcott. Amer. Soc. for Test. Materials, Vol. XX, Part II, 1920.

DISCUSSION.

L. N. Edwards.*— I appreciate your courtesy in calling upon me to discuss the paper read by Mr. Young, but on account of the lateness of the hour I shall refrain from entering into a lengthly discussion. I desire, however, to call attention to a few phases of the surface-area method of proportioning mortars and concretes, which appear to me to have been but lightly touched upon.

Speaking generally, seventy-five to eighty-five per cent. of the total volume of a concrete is made up of sand and stone aggregates. The strength, hardness, toughness and other physical properties of these aggregates are, therefore, most vital factors in the production of reliable concrete construction work. The extent to which the physical properties of the parent rock remain unchanged in our sands and gravels depends very largely upon the agencies by which these aggregates have been produced. Naturally enough, the sands and gravels produced by the crushing and abrasive action of the glaciers of the Ice or Glacial Age have undergone less change than have those produced

* State Highway Commission, Augusta, Me.

by the weathering, decomposing, and disintegrating agencies of all ages. Very briefly, the basic conditions affecting the reliability of our sands and gravels are:

1. The physical properties of the parent rock.

2. The conditions attending the disintegration of the rock mass.

The surface-area method of proportioning produces, I believe, a practicable means of discovering the mortar and concrete-making qualities of sands and of gravels by which we may learn the strength, hardness and other desirable qualities procurable from their use, with the most economical proportioning of the cement content.

In general, the strengths of concretes are primarily dependent upon the strengths of their mortar contents. The strength of the stone aggregate becomes a dominating factor when its strength is less than the strength of the mortar surrounding it in the concrete mass. The fact that the fractured surface of a concrete shows the particles of stone aggregate (particles of gravel or of broken stone, as the case may be) broken through does not necessarily indicate that practically the same strength could not have been secured with a less cement content, other conditions being equal.

The increasing use of concrete as a structural material and the fact that this use is distributed throughout the entire area of practically every state in the Union would seem to indicate the importance of the making of a general survey of the concrete materials to be found in any given state and the development of information relating to their concrete-making qualities. I believe you will agree with me that a survey of this kind, undertaken even at a comparatively small expense per annum, would provide in a comparatively small number of years the information necessary for charting the locality of available concrete materials and the tabulation of important information concerning them. Doubtless the information thus made available would ultimately result in an economy in the use of cement. However, the securing of structures fulfilling the requirements of their design is a matter of special importance to us as engineers.

In connection with the bulking effect of moisture in sands

there exists an interesting detail which is of no special value in so far as concrete making is concerned. In a series of tests made in 1917,* I found that when the moisture content is sufficient to produce a flooded condition of the sand, the volume becomes the same as the original volume of dry sand. In no case did I find that the water had the effect of producing a decrease of this volume.

* Proceedings Am. Soc. for Test. Mats., Vol. XXVIII, Part II, page 235.

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PAPERS AND DISCUSSIONS

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SEVERAL YEARS' EXPERIMENTS ON THE DISPOSAL OF WORCESTER SEWAGE.

By Roy S. Lanphear.*

(Presented before the Sanitary Section, February 2, 1921.)

The chemical precipitation plant for treatment of Worcester sewage was placed in operation March 25, 1890. Experimental treatment of sewage on a large scale commenced in 1900, when settled sewage, chemical precipitation effluent and septic tank effluent were run on to sand filters which had been recently constructed. Two years later, filtration of septic tank effluent was abandoned because finely divided suspended matters penetrated the surface of the filters and required frequent removal of large quantities of dirty sand. Settled sewage from the chemical precipitation basins gave similar results of operation. Chemical precipitation effluent also carried finely divided solids on to the sand filters and the precipitation of lime resulted in the formation of a hard crust of the top sand. The rate of filtration of chemical precipitation effluent decreased more than 50 per cent. in five years, and it was necessary to remove as much as 4 ins. of material in a single cleaning in order to regain the original rate of filtration.

Late in 1904, facilities were provided for delivering crude sewage directly to the sand filters, which method of operation continued until September, 1908. Change was then made to

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the present method of passing the sewage through one or two settling basins which afford a short detention period of about twenty minutes. This change was made to relieve the overloading of the sand filters with scum close to the distributors. The disposal of suspended solids as sludge by pumping is much cheaper than the removal from the filters, and the short detention period of the sewage removes only the heavier and coarser suspended solids.

Experimental sewage treatment plant operation commenced in 1905, when septic tank effluent and settled sewage were put on to contact filters; two primary beds and one secondary bed, each about 1 200 sq. ft. in area, were filled with 40 ins. of depth of crushed stone, $\frac{3}{4}$ to $2\frac{1}{2}$ ins. in size. The results of operation were unsatisfactory with each influent; a rate of 500 000 gals. per acre daily gave a putrescible effluent much of the time, and the loss of capacity of the beds in a single year was 12 per cent., 4 per cent. during the first six months and 8 per cent. during the second six months.

In 1906, the depth of the primary beds was increased, the stone removed, and they were used as septic tanks for one year, when one tank was operated as a settling tank for septic tank effluent, all as preliminary treatment for trickling filters of 5 and $7\frac{1}{2}$ ft. in depth. Two years later, preliminary treatment was changed to plain sedimentation of sewage, and in 1911 chemical precipitation effluent was applied to the shallow filter. Much valuable data was obtained, but the principal results may be stated as follows:

1. The deeper filters gave the better effluent.

2. Purification was better with septic tank effluent than with settled sewage because ferrous iron of the sewage was removed to some extent in the septic tank by precipitation as sulphide of iron.

3. The odors accompanying filtration of septic tank effluent were very objectionable.

4. Chemical precipitation effluent was filtered at a rate of 1 000 000 gals. per acre daily, and settled sewage at 700 000 gals. per acre daily with equally good results.

5. The cost of chemical precipitation eliminated the consideration of this process as preliminary treatment.

In 1911, an Imhoff tank and two trickling filters were placed in operation, each filter being 10 ft. deep, one with crushed stone $\frac{3}{4}$ to $2\frac{1}{2}$ ins. and the other $\frac{1}{2}$ to $1\frac{1}{2}$ ins. in size. This plant was operated successfully for two years, the rate of filtration during the second year being 2 million gallons per acre daily. The filter of coarser stone did not yield quite as good an effluent as the other, but caused much less trouble with surface pooling of water. Its effluent was non-putrescible during warm weather, and during the winter about 75 per cent. of the samples tested were non-putrescible.

It was appreciated that chemical precipitation of sewage was inefficient and costly, and in 1916 the superintendent of sewers recommended the change to an Imhoff tank-trickling filter sewage disposal plant. The construction of sand filters was discontinued in 1910, when the supply of sand became depleted. About the time of this recommendation, the State Department of Health started considerable agitation for a new sewage treatment plant of the type recommended.

Early in 1917, in keeping with the policy of the Worcester Sewer Department to test out every method of sewage treatment that gave promise of success, an experimental plant using the activated sludge process was constructed and placed in operation. This plant was operated for thirteen months, at the end of which time the supervising chemist was called to military service. During the operation of the plant, difficulty was experienced in obtaining and holding a sufficient number of qualified assistants. Consequently the report upon the operation of the plant was not ready to submit to the superintendent of sewers until November, 1919. This report indicated that the air requirements of Worcester sewage treated by the activated sludge process were large and that disposal of the sludge presented a serious problem.

On May 9, 1919, six months before this report was available, the state legislature, at the instigation of the State Department of Health, passed an Act requiring the city of Worcester to start work on a new sewage disposal plant before October 1, 1919, and to place the plant in operation by April 1, 1924. With no opportunity for the consideration of possible need of further experimentation, the Superintendent of Sewers again recom-

mended that the Imhoff tank-trickling filter process of sewage treatment be adopted, and the State Department of Health approved the same and the proposed location of the plant. The site of this plant is being cleared and the outfall sewer is being extended to the new plant.

Experimental Activated Sludge Plant.

Description. — The experimental activated sludge plant consisted of a bar screen, grit chamber, sewage aëration tank, sludge re-aëration tank, sedimentation tank, sludge concentration tank and a shallow tank used for sludge concentration experiments and for measuring excess sludge previous to disposal.

Sewage was taken from the outlet of the main grit chambers in a 6-in. pipe line to the screen chamber, where it passed through the screen with $\frac{1}{2}$-in. openings between the bars. It then passed in a trough, by a swivel gate, where excess quantities of sewage were wasted, to a grit chamber, 72 x 10 x 8 ins. deep, formed by a depressed section of the trough bottom. The sewage flow was measured by a weir and hook-gage and then continued in the trough to the sewage aëration tank, the returned sludge entering this trough close to the tank.

The sewage aëration tank was constructed of wood and had a concrete bottom; it was 26 ft. long, 14 ft. wide and 10 ft. deep, — water depth, — and had a capacity of 25 283 gals. The tank was divided into three channels, giving the sewage a travel of nearly 80 ft. The bottom of the tank was of saw-tooth construction, rows of four filtros plates, Grade "S," being placed 45 ins., center to center, giving a ratio of tank surface to working plate area of 5.2 to 1. Concrete blocks were placed between the rows of plates and had slopes of 1.5 on 1. Compressed air was delivered by a 4-in. header to three $2\frac{1}{2}$-in. pipes, one for each channel. Each set of filtros plates was supplied with air by a 1-in. pipe which entered a chamber under the plates made by using a form when putting in the concrete bottom. Each of these pipes had a valve near the top whereby the quantity of air passing to each set of plates could be regulated, but much care had to be exercised in their use in order to avoid trouble.

This method of installing the filtros plates proved very successful, and it is noted that the general use of metal holders is being abandoned. Filtros plates proved satisfactory for the diffusion of air into the sewage and sludge; brushing of the plates was done once, and apparently did no good. Each 1-in. pipe was fitted with a union so that perforated pipe distributors could be substituted for the filtros plates, but results of operation did not warrant such a change during the second summer. No baffles were used in either aëration tank, but such installation in the sewage aëration tank had been considered.

The effluent from the sewage aëration tank passed in a trough to a point above the center of the sedimentation tank and was measured by a weir and hook-gage. The inlet to the sedimentation tank was a box of increasing area of cross-section which extended down into the tank about 8 ft. This tank was of the Dortmund type, 14 ft. in diameter and 9.6 ft. deep, circular section, with a conical bottom, 9 ft. deep, having a slope of 1.5 on 1.0. The capacity of the upper section was 11 058 gals., and of the conical bottom, 4017 gals. During operation, the conical bottom was usually kept filled with sludge to aid in returning sludge to the sewage which had sufficient and uniform density. The sludge did not slide down this slope readily, and a squeegee was used daily. The effluent was collected in a circumferential trough and the sludge settling to the bottom of the tank was raised by air lift and delivered in a trough, containing swivel gates, to the sewage or sludge aëration tanks or to either of the sludge tanks.

The sludge, with or without re-aëration, was returned to the sewage in a trough previously mentioned, and was measured as the difference of the combined sewage and sludge and the sewage flows. The sludge re-aëration tank was 12 ft. long, 5 ft. 4 ins. wide and 10 ft. deep, and had a capacity of 4 386 gals. Its construction was similar to that of the sewage aëration tank and the ratio of tank surface to air diffuser area was 4.76 to 1.0.

The equipment for furnishing compressed air included two 10 h.p. single-phase motors, belt-connected to two No. 2 Nash hydroturbine compressors or blowers. The air passed through cheesecloth screens and was washed with water in the compres-

sors. Air used for aëration of sewage and of sludge was measured by Venturi meters connected to graduated manometer tubes, and that for the air lift, by a Westinghouse No. 12 gas meter. A pressure gage, thermometer and a waste valve were suitably installed in connection with a storage tank placed between the compressors and the separate air supply mains. The quantity of air used was regulated by adjusting the valves on each supply main and the waste valve. On this account, together with interruptions of operation and the operation of one or both compressors, the pressure data are inconsistent. The average pressure increased from $5\frac{1}{4}$ lbs. to about $6\frac{1}{2}$ to $6\frac{3}{4}$ lbs. in the winter, and during the second summer dropped to from $5\frac{1}{2}$ to 6 lbs., indicating the probability of slight clogging of the filtros plates. The higher pressures of winter may be explained in part by interruptions of operation and by the probable increased friction in the air distribution system due to condensation. The air distribution pipes were protected from the winter temperatures by covering with felt and boxing them in.

Operation. — From 125 000 to 165 000 gals. of sewage were screened daily, the screen raked once an hour, and an average quantity of 11.4 cu. ft. of screenings removed per million gallons of sewage screened. Fine screening is apparently not necessary for successful operation, but might result in the reduction of the quantity of air required. On account of the large oxygen requirement of Worcester sewage, due to the presence of large quantities of trade-wastes, the reduction would be relatively small. According to Mr. Hatton, of Milwaukee, fine screening of sewage in this process of treatment should not be carried too far because the resulting activated sludge is difficult to de-water.

The results of operation of the small grit chamber indicate that the treatment of combined sewage by the activated sludge process requires careful design and operation of the grit chambers.

Careful records were kept of all temperatures of operation, and it may be stated that winter operation of the activated sludge process in New England climate is generally possible. For a period of six weeks, the average maximum temperature of the air was below 32 degrees Fahr., and the average minimum below 10 degrees Fahr.; during the first week, the maximum

daily temperature varied from 4 degrees to 18 degrees Fahr., and the minimum from −16 degrees Fahr. to −2 degrees Fahr. The results of operation during this period of six weeks were good.

The quantity of sludge returned to the sewage was regulated according to the results of a thirty-minute settling test of the effluent from the sewage aëration tank, the test being made by reading the volume of settled sludge in a 500 c.c. graduated cylinder. Activated sludge in proper condition settles rapidly in this thirty-minutes settling test and after ten minutes will be only about 50 per cent. greater in volume than at the end of the test, and during the last twenty minutes, it settles as a mass or compacts. Variation of density of the sludge and its effect upon the bulk of solids or flocculent sludge necessary for clarification of the sewage are offset by maintaining a uniform percentage of sludge according to this test. Excessive quantities of sludge without sufficient solids always produced an unsatisfactory effluent having a yellow or brown color, while in what might be termed successful operation the supernatant water above the settled sludge had very little turbidity and was colorless. At times, this supernatant water was as clear as spring water within a few minutes after the collection of the sample. This settling test was an excellent indicator of the character of the sludge and the effect of the quantity returned to the sewage. The percentage of solids in the settled sludge in this test was generally greater in the effluent than in the influent, the maximum differences, about 0.2 per cent., occurring when the greater quantities of air and longer periods of aëration were used.

Comparison of results of this thirty-minutes settling test made at the inlet and outlet ends of the sewage aëration tank showed a variation of not more than 0.2 per cent. of sludge. Apparently, precipitation of iron is rapid or aëration of sludge in this tank results in a better settling sludge, and the precipitated iron and suspended solids from the sewage cause no marked difference in the results of the test.

Foaming occurred in the sludge re-aëration tank during the first ten days of operation, and it was necessary to raise the tank walls 9 ins. and cover the tank with chicken-wire to prevent the foam going over the walls. Foaming occurred at other times, usually with the aëration of activated sludge of poor quality.

The character of the re-aërated sludge could be observed quickly by putting a small quantity into some water contained in a glass cylinder. A thirty-minutes settling test of the re-aërated sludge usually gave a percentage of sludge of from 96 to 98; the specific gravity and per cent. solids of the settled sludge varied from 1.010 to 1.015 and from 1.00 to 3.40, respectively, the heavier sludge occurring in the summer season with the use of the larger quantities of air. The water above the settled sludge always had a yellow color, the intensity varying with the color of the sludge. The odor of the re-aërated sludge was generally characterized as a combination of musty, earthy and wormy.

Analyses of the air after use in the aëration tanks showed that oxygen was removed and carbon dioxide formed, about 2.1 and 4.3 per cent. in the sewage and sludge aëration tank, respectively. A small amount of methane and heavy hydrocarbons was also formed.

The sedimentation period of the aërated sewage and sludge, based on the cylindrical portion of the sedimentation tank, varied from 1.6 to 2.9 hrs., which is much longer than is generally considered necessary. This period can probably be shortened, but provision should be made for the continuous removal of reasonably dense sludge, as experience has demonstrated that the return of large volumes of thin sludge to the sewage aëration tank is undesirable. It will also be necessary to arrange for the removal of unsightly grease balls and scum from the water in the sedimentation tank.

Quality of Final Effluent. — The rates of operation will be considered in the next paragraph. Chemical analyses of sewage and final effluent showed a general lack of reduction of free ammonia, considerable reduction of albuminoid ammonia and oxygen consumed, from 85 to 95 per cent. removal of suspended solids, about 90 per cent. removal of iron, and an entire absence of nitrification of the effluent. Clarification was generally excellent and in the absence of nitrification exerted considerable influence upon the stability of the effluent. The dissolved oxygen content of the effluent usually averaged from 20 to 30 per cent. of saturation, but many times was zero in the afternoon.

In general, effluents having less than 0.2 part of total albuminoid ammonia, about 0.05 part per 100 000 of suspended albuminoid ammonia and less than 3.0 parts per 100 000 of suspended solids were of good appearance, but the stability was variable, being influenced by the actual content of organic matter and suspended solids. The effluent usually contained from 50 000 to 350 000 bacteria per c.c. according to the quality, a maximum reduction of 97.5 per cent. being obtained when the maximum quantities of air and periods of aëration were used.

Results of Sewage Treatment. — From 75 000 to 125 000 gals. of sewage were treated daily, using from 2 to 5 cu. ft. of free air per gallon and periods of aëration of sewage from 3.8 to 6.2 hrs. and of sludge, with the exception of one period of six weeks, from 2.8 to 6.5 hrs. The size and character of the plant confined the operating schedule within certain limits in order to obtain accurate records; changes would have been advisable if the operation had not been interrupted.

1. A total quantity of 1.75 cu. ft. of free air per gallon of sewage, together with 3.8 hrs.' aëration of the sewage and 3.1 hrs.' re-aëration of the sludge, using 31 per cent. returned sludge, did not remove the color of the trade wastes from average sewage.

2. A total quantity of 2.16 cu. ft. of free air per gallon of sewage, together with 5.3 hrs.' aëration of the sewage and 5.3 hrs.' re-aëration of the sludge, using 21 per cent. returned sludge and treating weak sewage, gave an effluent having an average stability of about 90 per cent.

3. A total quantity of 1.99 cu. ft. of free air per gallon of sewage, 4.3 hrs.' aëration of the sewage and no re-aëration of the sludge, using 18 per cent. returned sludge and treating very weak sewage, gave an effluent having an average stability of about 60 per cent., but of good chemical quality.

These three statements practically define the treatment of weak Worcester sewage according to the degree of stability desired. Three or four days' stability of the effluent can be obtained without re-aëration of the sludge, when using at least 2 cu. ft. of free air, from 4 to 5 hrs.' aëration of the sewage and about 20 per cent. returned sludge.

4. A total quantity of from 3.3 to 3.6 cu. ft. of free air per

gallon of sewage, 6.3 to 6.5 hrs.' aëration of the sewage and 5.0 to 6.5 hrs.' re-aëration of the sludge, using about 25 per cent. returned sludge and treating fairly strong sewage, gave an effluent having an average stability of about 90 per cent. This result did not always obtain, and the variation or inconsistency is attributed to the character of the sewage.

5. A total quantity of 4.95 cu. ft. of free air per gallon of sewage, 6.3 hrs.' aëration of the sewage and 5.1 hrs.' re-aëration of the sludge, using 27 per cent. returned sludge and treating hardly average sewage, gave an effluent having perfect stability.

6. The results indicate, but with considerable uncertainty on account of the inability to duplicate, that a total quantity of about 4 cu. ft. of free air per gallon of sewage, 6 hrs.' aëration of the sewage and 6 hrs.' re-aëration of the sludge, using about 25 per cent. returned sludge and treating average to strong sewage, should give a final effluent of good chemical quality and having a stability of from 75 to 90 per cent.

7. Elimination of re-aëration of sludge while treating average to strong sewage was not attempted on account of the poor results of the second summer and the interruption of operation of the plant.

Summary of Sewage Treatment. — Worcester sewage contains much trade wastes of such varying character and quantity that nitrification did not take place with the quantities of air and periods of aëration used in the operation of the experimental activated sludge plant. A stable effluent was obtained by the reduction of the organic content of the sewage. Lack of nitrification and low dissolved oxygen content of the effluent furnished no factor of safety or stability, such as is usually present in effluents from biological processes of treatment; consequently, sewage of greatly varying character was not uniformly well treated. Increased quantities of air and periods of aëration would probably overcome the sensitive character of the activated sludge process in treating Worcester sewage and give uniformly good results with apparently similar conditions of treatment.

Comparison of Effluents. Activated Sludge and Imhoff Tank-Trickling Filter Methods of Sewage Treatment. — It has been stated that the activated sludge effluent was generally clear,

colorless and of good chemical quality but lacked stability. Treating stronger sewage and operating at a rate of 2 000 000 gals. per acre filter daily, the Imhoff tank-trickling filter experimental plant gave an effluent which was generally slightly turbid, slightly colored at times, of greater organic content, but contained about 0.5 part per 100 000 of nitrogen as nitrates, and was perfectly stable during the warm weather, and 75 per cent. of the samples were non-putrescible during the winter season.

Activated Sludge. — The satisfactory treatment of sewage is usually considered a prerequisite to investigation of methods of sludge disposal, but the extremely large quantity and unusual character of activated sludge produced presented a problem which was of much interest. Activated sludge is flocculent, settles rapidly and has a brown color, the particular shade of which is very variable and apparently due to changes in the character of the sludge. A very dark brown color and loss of flocculent character indicated insufficient aëration, and a very light brown color and a change from flocculent condition to finely divided solids indicated over-aëration. The odor of good activated sludge was generally characterized as earthy, and when not so good its odor resembled that of decaying angleworms, similar to that of sludge from final settling basins following trickling filters.

Sludge Production. — The quantity of activated sludge produced per million gallons of sewage varied from 12 000 gals. in summer to 25 000 gals. in winter; both quantities are much greater than have been produced by any other process of treatment of Worcester sewage. The sludge contained from 97.1 to 98.7 per cent. moisture, the denser sludge being obtained in the summer. The dried sludge contained from 50 to 70 per cent. of organic matter, from 8.5 to 18 per cent. of iron, from 2 to 9 per cent. of fats, and from 4.0 to 6.5 per cent. of nitrogen. Worcester activated sludge was as dense as that which has been obtained elsewhere, and indicates that it will be difficult to obtain activated sludge, without concentration, having less than 97 per cent. moisture.

Air Drying of Sludge. — The greater part of the sludge was dried upon sand beds; this method of disposal is impractical on

account of being unable to dose the beds to a depth greater than 4 or 5 ins. If more than this quantity was applied, the sludge settled rapidly and water remained on top, which had to evaporate before actual drying commenced. The dose had to be of such size that the bulk of the water drained away during application to the bed: cracking of dried sludge commenced after twenty-four hours, and removal was possible twenty-four hours later. The usual dose was from 2.0 to 2.5 gals. per square foot of drying bed area. Concentration of sludge improved results very slightly.

Concentration of Sludge. — The first step in disposing of activated sludge on a large scale would be concentration, in order to decrease the volume to be handled. Concentration experiments were made in two tanks, one of which was 14 ft. in diameter, 6 ft. deep and held 2 000 gals.; the other was 3 ft. in diameter, 18½ ft. deep and held 650 gals. Heavier sludge could be drawn from the bottom of the deep tank if extremely long periods of concentration were used, but in no instance was sludge obtained containing less than 95 per cent. moisture. Concentration of sludge for from fifteen to twenty-four hours decreased the volume of sludge about 50 per cent. and its water content from 98 to 96 per cent., the best results being obtained when the sludge was in a flocculent condition. Character of sludge effects the quantity to be handled; that is, poor results of operation as regards sewage treatment may mean increased cost of sludge disposal.

Pressing of Sludge. — A section of a press of the Bushnell type, formerly used for chemical precipitation sludge, was demonstrated to be unsuitable for pressing activated sludge, unless about 2 500 lbs. of lime in the form of milk of lime were added to 100 000 gals. of sludge and pressing made for about two hours at 60 lbs. per square inch pressure. Without the use of lime, various results of pressing were obtained, depending somewhat upon the character of the sludge; but in all cases radial streaks of soft sludge were formed which rendered the press cake unfit for disposal. Our present installation of sludge presses is unsatisfactory for handling activated sludge without preliminary treatment. The results indicated that the successful press should de-water the sludge to about 70 per cent. mois-

ture during the first twenty to thirty minutes of operation, and the addition of lime should not be necessary.

Sludge as Fertilizer Material. — The nitrogen content of activated sludge is greater than that of any other sewage sludge at Worcester. Fertilizer analyses of activated sludge, Imhoff tank and final settling basin sludges are given as follows, the results being percentages and given in the above order.

Substance.	I.	II.	III.
Total nitrogen	4.06	2.61	2.42
Available nitrogen	1.39	1.25	1.71
Total phosphoric acid	2.26	1.66	3.43
Citrate insoluble acid	0.50	0.46	1.16
Citrate soluble acid	1.76	1.20	2.27
Potash*			

* Not determined, varies from 0.0 to 0.05 per cent.

The available nitrogen in the Imhoff tank sludge is but little less than that in the activated sludge, while the final settling basin sludge contained considerably more than did activated sludge. The final settling basin sludge also contained much more total and citrate soluble phosphoric acid than did activated sludge. The actual nitrogen content of activated sludge as compared with combined Imhoff tank and final settling basin sludge, based on unit quantity of sewage treated, is approximately $2\frac{1}{2}$ times as great. If revenue was desired along these lines, facilities would have to be provided for handling six times as much unconcentrated and three times as much concentrated activated sludge as of the combined sludges, and about one and one-half times as much dry solids.

Summary. — The operation of the experimental activated sludge plant for a period of thirteen months demonstrated that this process of treatment of Worcester sewage will produce an effluent of excellent appearance and good chemical quality. The quantity of air required was much greater than that which has been considered possible to use in other cities. This increased air requirement is due in great part to the necessity of reducing the organic content of the effluent to a relatively small

quantity in the absence of any nitrogen as nitrates, in order to obtain a stable effluent. The problem of disposal of large volumes of sludge each day was only partially solved, but it was demonstrated that our present sludge press installation was not suitable for handling activated sludge.

Vol. VIII APRIL, 1921 No. 4

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ADDRESS AT THE ANNUAL MEETING.

By Frank A. Barbour, President, Boston Society of Civil Engineers.

(March 16, 1921.)

The Engineer in Service of the Public.

That Herbert Hoover — an engineer — is the most outstanding personality in the world to-day should be of significant moment to all members of the profession. By his work as chairman of the Commission for Relief in Belgium, United States Food Administrator and Director-General of the American Relief Administration, he has, in the years since 1914, become an object of intense interest to millions of the people of this and many other countries, and, of all the great names connected with the recent world catastrophe, his is the one which most clearly stands for constructive public service, for re-habitation and for direct helpfulness to suffering humanity.

This is a record in which engineers may well find inspiration, but Mr. Hoover has more directly challenged the attention of the profession by the clear call to public service which, as president of the Federated American Engineering Societies, he has recently sounded.

And so it has appeared to me that a brief outline of the career of this man who has suddenly revealed to engineers the possibilities of joint professional effort in helping to find a way out of the present industrial morass may not prove unprofitable to this Society. If the address required of all expiring presidents

is assumed to carry some message of general value to the membership, I may, perhaps, be pardoned for seeking this message in the example and precepts of Herbert Hoover.

Born August 10, 1874, in the little village of West Branch, Ia., Herbert Clark Hoover graduated in 1895 from Stanford University — having in great part earned his way through school and college by work of various kinds. After a few months of regular pick-and-shovel mining he entered the office of Louis Janin, a leading mining engineer of the Pacific Coast, and two years later was recommended by his employer to an English company who were seeking a man to investigate and manage mining properties in West Australia. Seizing this opportunity, he justified Mr. Janin's regard, and, under most difficult conditions of climate, lack of water and an ore requiring technical originality for successful working, he put previous non-paying properties on a sound basis, discovered and developed a big new mine, and, at the age of twenty-four, had established a reputation in Australia and London.

At this point there came an invitation from China to become "director-general of mines" of that country, and, accepting, he traveled thither via London and America, stopping a few days in California to get married, and sailing for the Orient in February, 1899. The government connection was terminated a year later by the Boxer Uprising, and he then became consulting engineer and general manager of the Chinese Engineering and Mining Company, making a success of the great Tonshan coal properties, building railroads, cement works, a harbor, and superintending the operation of 20 000 employees and a fleet of ocean steamers.

Returning to London in 1902, Mr. Hoover was made a partner in the mining firm for which he had worked in West Australia, and in the following six years — with branch offices in New York and San Francisco — his engagements took him to all parts of the world, and he acquired a reputation for unusual ability in organization and administration.

In 1908 Mr. Hoover opened an office in London for the independent practice of his profession, and found his first large success in the upbuilding of the great Broken Hill Mines in South Australia. Rapidly his reputation for making broken-down

properties going concerns grew, and he soon became consulting engineer and managing director of a score of mining companies. Among his undertakings were the iron and copper mines at Kyshtin in the Urals, the zinc, iron, lead and coal mines on the Irtish River in Siberia and the silver-lead mine in Burma, India, which has since become the greatest mine of its type in the world. Other operations under his direction were in Mexico, Colorado, Korea and South Africa, and in 1914 — when his professional activities suddenly ceased — about 175 000 men were engaged in the working of the various properties with which he was connected. He had, at the age of forty, reached the pinnacle of professional success.

And then came the war, and immediately Herbert Hoover found work in helping 70 000 stranded American travelers to get home, he and some friends first advancing several hundred thousand dollars against personal checks of unknown fellow-countrymen, and subsequently — at the request of Ambassador Page — taking charge of the distribution of the gold forwarded by the American Government for relief of the situation.

The capacity for organization and quick decision displayed in this preliminary skirmish in public service marked him for further work, and when, within a few weeks after the opening of the war, it became evident that, through some neutral agency, food must be furnished to the 10 million people imprisoned behind the German lines in Belgium and France, he was called to head the Commission for Relief in Belgium.

The situation was extremely difficult; the Germans were refusing to feed the people behind their lines, the Allies were blockading Belgium as well as Germany, and the imprisoned millions were in imminent danger of starvation. To convince both sides that strictly neutral relief was possible required diplomacy of the highest order, but consent was obtained and the work began. It is an epic in philanthropy — this feeding of 10 million people for fifty months — but the money was raised, the food purchased, transported to Rotterdam, transferred to canal boats and distributed to the non-combatant population behind the enemy lines in France and Belgium. Almost a billion dollars were expended by the Relief Commission in this

work, with an overhead of a little over one half of one per cent. Herbert Hoover had applied engineering efficiency to philanthropy.

And then, with the entrance of the United States into the war, there came to this engineer the call from the President that he take the thankless but all-important job of conserving the food supply of this country and so of the Allies. How successfully this was done is a matter of history. Starting in May, 1917, and without legal authority, until the passage of the Food Control Law in August, Mr. Hoover, by a wonderful appeal to the reason and hearts of the people through publicity, brought home to each individual the necessity of conservation. And then later, under a law, inadequate in many ways, he undertook the elimination of speculation and waste, the stabilization of prices in essential commodities so as to stimulate production, and, by coöperation with the war trade and shipping boards, the control of food exports — but always with as much of administration and as little of dictation as conditions would permit. Decentralization of authority and the carrying of responsibility to the individual were the keynotes of the work, and the results justified the method.

And then came the armistice, and once again the President called Mr. Hoover to great world service as Director-General of the American Relief Administration in Eastern Europe — a work which, while less known in this country, proved to be, perhaps, the greatest of all his public activities.

The Baltic States and the people of the Near East were in a condition of economic wreckage and starvation, Russia was in the hands of the Bolshevists, and, if the spread of anarchy were to be stopped, assistance in obtaining food and clothing and in re-starting the economic movements essential to life must be furnished to these newly liberated nations. Chosen Director-General of Relief by the Supreme Economic Council of the Allies, Mr. Hoover — with some 160 million dollars advanced by the United States and Great Britain — distributed to twenty different countries in six months, from December, 1918, to June, 1919, about 3¼ million tons of supplies, of a value of about 800 million dollars. With the whole transportation system

placed in his control and with food and clothing at his command, he became the general manager of Southeastern Europe, and while the Peace Conference talked he saved nations; and to this relief work done under his direction more than to any other factor it is due that anarchy and Bolshevistic domination did not spread over Europe, west of Russia.

Returning to America in the latter part of 1919, Mr. Hoover has continued his work for the re-habitation of Europe — acting as chairman of the American Relief Administration and recently leading to success the campaign for the raising of 33 million dollars for the European Children's Fund.

It has seemed to me that the record of this engineer in the service of humanity must be an inspiration to all members of the profession. We cannot all be Hoovers, but we can catch the spirit of service and the sense of individual responsibility to the public welfare.

But not only by example but also by precept is Herbert Hoover calling the engineer to a more active part in the service of the public. Elected president of the American Engineering Council — the administration body of the Federated American Engineering Societies — he at once projected on the screen a new and larger picture of the possibilities of joint action by engineers in helping to solve existing economic problems. He sees the engineer as a possible bridge between the employer and labor, and in the quantitative and constructive mind of the profession he finds the best chance of reaching a betterment of present industrial conditions.

Reviewing the whole economic situation and stressing the necessity of maximum production and the elimination of all avoidable wastes, he ends his first presidential address to the council in the following words:

"I am not one of those who anticipate the solution of these things in a day. Durable human progress has not been founded on long strides. But in your position as a party of the third part to many of these conflicting economic groups, with your lifelong training in quantitative thought, with your sole mental aspect of construction, you, the engineers, should be able to make contribution of those safe steps that make for real progress."

And three months later, on February 14, in another address we find him outlining a preliminary survey "of some of the weaknesses in our production system" in an attempt "to visualize the nation as a single industrial organism and to examine its efficiency towards its only real objective, — the maximum production." This survey, which is already started and which will involve an investigation of "the whole question of deficiency in production or of industrial waste in a broad sense," is the first public work of the Federated American Engineering Societies.

It is a big job, but the leadership of Herbert Hoover foretells success, and the doubter may well suppress his skepticism in the face of the past record of this man in translating creative vision into fruitful results, and, if it appears to any one that this excursion into the industrial field is a venture beyond the proper sphere of an association of engineering societies, let him ask himself by what class of men can the work be better done?

It will not do in this time of social unrest to simply trust that somehow the world will muddle back to stable conditions. "Wanting nothing from the public, either individually or as a group," engineers "are indeed in a position of disinterested public service." It is for us to catch some of the Hoover spirit of self-sacrifice, — *the will to serve;* and the awakening to a new sense of our opportunities and responsibilities will lift the profession to a place in the life of the nation hitherto unrealized.

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THE RESPONSIBILITY OF ORGANIZED LABOR FOR THE STAGNATION IN THE BUILDING INDUSTRY.

By Charles R. Gow,* Member Boston Society of Civil Engineers.

(Presented March 24, 1921.)

THE remarks which I shall make to you upon this subject are not directed against the fundamental principles of labor unionism, but rather are intended to be in the nature of a somewhat frank criticism of certain unsound practices on the part of many unions which have resulted in very serious economic consequences to the building industry of this city.

I am aware that one may not in these days raise his voice in protest against any act or motive of union labor without being promptly classified by the labor group as an avowed opponent of the entire labor movement.

Intolerance on the part of labor spokesmen toward the opinion of others and their heated and often bitter resentment of all criticism have rendered it extremely difficult for true friends of labor to counsel moderation or to urge measures for labor's ultimate welfare.

It is my judgment that there may be several advantages both to the employer and to the public in dealing with labor unions which are intelligent and responsible in their conduct and practices. When, however, the obvious disadvantages of such dealings outweigh the benefits to be derived therefrom, there is no compunction, either legal or moral, which requires

*6 Beacon Street, Boston, Mass.

the community at large to subordinate its interests to those of organized labor.

If an act is wrong at all, it is just as wrong when committed by a labor union as it would be if done by a highwayman or any other evil person.

During the war, as most of you are aware, I served as an army officer in charge of constructing the Army Supply Base at South Boston. This project entailed an expenditure of, approximately, $24,000,000 and the employment of a maximum of 7,500 workmen. Under the terms of the so-called Baker-Gompers agreement, this work was carried on as a closed shop job and in conformity with the working rules and agreements of the several trades unions employed in its construction. As a consequence, I received a very liberal education in the aims and policies of the unions as applied to the building industry. This experience, somewhat amplified by later contact and study along similar lines, has rather alarmed me as to the future welfare of the building industry in this locality, provided some of the present tendencies are not checked, and I shall try to present to you, as briefly as possible, an outline of the situation as it appeals to me.

It is customary to consider the cost of a building as being made up of the cost of the materials delivered at the site and the cost of labor used in assembling these materials in the completed building. Strictly speaking, however, there is no such thing as materials, unless we refer to the raw products in their natural state in the ground or in the forest. That which we speak of as material is merely the result of the combined labor which has gone into the production, manufacture and transportation of these raw products. True, a portion of the labor is contributed by the owners of the mine, of the mill or factory, of the railroad or by the distributor, and it may also sometimes be true that the wages paid to these owners in the form of so-called profits are in excess of a reasonable return for the amount and character of service rendered.

However, numerous laws have been established which prohibit employers such as those referred to from combining

into unions for the purpose of fixing their wage or profit, or of agreeing upon conditions under which they will render service. These laws, like all other laws, are sometimes evaded; but in the last analysis, by and large, the wages of this employing class are absolutely regulated by the immutable natural laws of supply and demand.

With respect to direct labor, however, the laws are much more generous. The right of paid employees to form unions for the purpose of fixing profits in the form of wages and of regulating conditions of employment is legally established and recognized.

This distinction between the two groups is of passing importance. We prohibit combinations by employers because we fear that such action might prove inimical to the public welfare through the increase and standardization of profits and the consequent advance in cost of the commodities which they handle. On the other hand, we permit and even encourage the wage-earning class to do the self same thing and in many respects they have taken full advantage of their opportunities. The economic effect upon the general public is the same in either case, whether costs be increased by combinations of employers or of employees.

There would seem to be no good reason why both groups should not be permitted to organize for their mutual protection and interest, but there is no moral right, and there should be no legal right, which would permit either group to combine for purposes which are detrimental to the interests of the community at large.

Statisticians have estimated that, on the average, at least 75 per cent of the cost of materials delivered on the site is on account of direct labor. Assuming this to be true, then at least 80 per cent of the cost of the completed building is represented by the direct labor item. Any general influence which increases labor costs must necessarily be reflected in a corresponding increase of the proportion in the cost of the completed building. On the other hand, if any substantial reduction is to be made in the cost of building construction, it must come chiefly through a readjustment of the 80 per cent item.

There has been a tremendous increase in labor cost during the past six or seven years. This increase has resulted from two principal causes, namely, increased rates of pay and decreased efficiency on the part of the individual worker. Such pay increases as have occurred have probably been justified in a large measure by the depreciated value of the dollar. Just why the same logic does not apply in the reverse order of things is one of the puzzling problems of the present situation which as yet remains unanswered.

The decrease of efficiency which has been especially marked during the past two or three years is likewise the result of two separate causes. First, the excessive demand for labor during the period of its maximum shortage produced a certain feeling of independence among the workers which was bound to result in more or less disregard for the wishes and welfare of the employer. It might also be said in passing that this attitude was not characteristic of any one class of employees but was noticeable generally wherever help was employed.

However, the inefficiency which resulted from this cause very largely disappeared some months ago with the advent of the present industrial depression and as unemployment became more general. It is safe to assume that no further trouble may be expected from this particular cause until the law of supply and demand again enthrones labor on its former pinnacle of prominent industrial importance.

The second and more serious cause of inefficiency is artificial, union made, and is in defiance of all economic laws and public welfare as well. It is with regard to this feature that I wish to devote my principal attention.

Until within a comparatively few years the building industry of this vicinity was represented by both closed and open shop contractors, so that there existed a certain degree of competition which prevented excesses by either group.

The superior organizing ability of the union leaders, backed by a strong public sentiment in their favor, led to the gradual elimination of the open shop contractor with the result that organized labor through the closed shop now holds practically a monopoly over the entire industry.

As a result of this situation, a non-member of a union cannot today find employment in a building trade in Boston except to a very limited extent. Consequently, practically all such men as a matter of necessity have joined the union pertaining to their trade because the closed shop jobs constitute their only sources of employment.

A non-union or open shop contractor from another city cannot do work in Boston because he is unable to secure his supply of labor here, such labor having been absorbed by the unions as already stated.

Individual contractors who might be inclined to change from closed to open shop conditions may not do so because, unless they could offer their men permanent employment (and this is not practicable), it would be unwise for their employees to leave the union and thereby restrict their opportunity for obtaining work to but one employer.

Also, general contractors are dependent upon subcontractors, such as the plumber, electrician, steam-fitter, etc., for work pertaining to those trades and union subcontractors would not be permitted to do work on an open shop job.

As a consequence of the monopoly thus established by organized labor in the building industry in this locality, there have been developed many practices of an arbitrary and autocratic nature which have seriously affected the interests of employers and public alike, and which if continued will tend to destroy the industry itself.

It has long been held by leaders of organized labor that whatever makes for the employment of a greater number of men is of direct benefit to the union, regardless of the method employed to secure the result, because it reduces the available supply of men and thereby produces a shortage for subsequent jobs, which in turn enables the union to dictate to a greater extent the terms under which their men will work.

One of the most common means adopted by the unions to force the employment of more men is the restriction of output by agreement. Thus, it was testified to by a number of

reputable builders at the recent Chamber of Commerce hearings that although brick masons formerly laid from 1,500 to 2,000 bricks per day it has now become the custom in that trade to limit each man to not more than 500 bricks per day. This greatly reduced output per man has so affected the available supply of brick masons, that during the past year contractors have been obliged to bid as high as $1.25 to $1.35 per hour to obtain their services at all, even though the established union rate was but $1.00 per hour.

At a rate of $1.35 per hour and a daily output of only 500 bricks laid, it will be readily apparent that it cost $21.60 per thousand bricks laid for the mason's time alone, exclusive of helpers or material. It is interesting to note that this price is substantially the same as the cost of brick at the kiln. In other words, the union brick mason receives as much money for the simple act of picking up a brick and placing it in the wall as does the manufacturer of the brick for the entire expense of excavating the clay, moulding and burning, handling and storing, including all overhead expense, interest and depreciation charges, bad debts, business risks, etc. Still, labor leaders have been loud in their condemnation of the brick manufacturer as an alleged profiteer.

As a net result of this campaign by the union for a reduction in output, the cost of the mason's time in laying brick has increased from about $2.00 per thousand to over $20.00, although the individual mason received but slightly more than double his former wages per hour.

A recent demand of the wood lathers specifies that twelve bundles of laths shall constitute a day's work. For the past few years sixteen bundles has been the average output and formerly thirty bundles per day was not an unusual output.

It was formerly the custom among many contractors to sublet various portions of the work to the workmen direct. Thus, the laying of brick, the applying of lathing, plaster, paint, etc., was frequently done upon a piecework basis. The men who undertook this work competed for it on a price basis and naturally exerted themselves to the utmost to produce the maximum of output and therefore of remuneration.

This practice has long since been prohibited by the several unions under penalty of a heavy fine for violation, the theory being that the increased production which resulted under this system deprived other union men of an opportunity for employment.

Another method which has been found by the unions to be efficacious in creating additional jobs for their members, has been the simple expedient of insisting that high priced skilled mechanics must be employed to do certain work which otherwise would naturally be done by unskilled labor and in some cases even might require no labor whatever.

Having secured complete mastery over the employers through this strategic position it has been a simple matter for the unions to dictate the entire labor conduct of the industry. Each union today has its so-called working rules which form an integral part of the written agreements which employers are obliged to accept if they expect to obtain the services of members of that union. These rules prescribe in more or less detail the requirements which must be observed by the employer and limit to a considerable extent the amount of service which a member may render.

While each union has its own particular rules, many of the provisions are more or less common to the great majority. Thus, substantially all such rules require that foremen shall be members of the unions in question. The effect of this provision is to subject the foreman to two conflicting influences. If he is loyal to his employer, he may be deemed offensive to his union; and if he satisfies the union, it very often is because he has been disloyal to his employer.

Formerly, a foreman was the recognized mouthpiece of the employer and assumed all the responsibilities and functions of the latter during his absence. He was charged with the duty of obtaining a satisfactory degree of service from all of the employees under his direction. The employer looked to the foreman alone for results and the foreman in turn exercised full authority over his men.

The relationship has been greatly altered in recent years by this requirement that foremen must themselves be mem-

bers of the unions pertaining to their craft and have, therefore, to be acceptable to the other members of the unions who are to work under them. In case a foreman for any reason becomes obnoxious to the men, a complaint is filed against him with the union officials and he is tried, not by a group of fellow foremen, but by members selected from the rank and file who have authority to recommend his suspension or expulsion from the union.

During the construction of the Army Base work a foreman's union card was taken from him and he was debarred by the union from further connection with the work. Upon inquiring of the union officials I was informed that the charge heard against him was that he used profanity to the men. It appeared that his case had been considered by a secret tribunal which had recommended his expulsion and the findings were approved by the union membership. The records showed that he was one of the most efficient foremen on the work in the matter of low production cost and satisfactory workmanship. It seemed clear to me at the time that he had been thus disciplined because of too much insistence upon results from his men.

The trade rules of the Carpenters' District Council provide as follows:

"While all foremen should prove their efficiency as such, they shall not rush, use abusive language or otherwise abuse workmen under their direction. A violation of this rule is punishable by a fine, expulsion from the job, or both."

A prominent Boston contracting concern wrote to one of its foremen requesting a report as to why his work was costing so much and proceeding so slowly. The foreman's reply in part, in his own words, was as follows:

> In regards to a foreman in any trade belonging to a Trade Union, it has a tendency to take away his authority, and he has not the control over the men that he would have, if he did not have to be one of them.
>
> He should be allowed to pick out and discharge his poorest men at any time, even when he is taking on more men, and should not always be afraid of getting in wrong with his

"Local," and having a fine put on him, which under the present conditions, they can do. That is one of the reasons that workmen of today are not doing a day's work, simply because they do not have to, and under the present conditions it is impossible to speed up the work with a Union Foreman in charge.

On about all work, there has always been a feeling of dissatisfaction among some of the men, that they were not being used the same as the others.

As there is always some undesirable work to perform, and you would naturally pick out your poorest men to do such work, the consequences are, complaints are taken to the "Local" and then your foreman is called down again, then again, when your poorer men are put to work with the others in almost all cases your work slows down to your slowest men, and until you can control such men, to grading them with a sliding scale, this trouble will always exist.

The rules of the Plumbers' Union provide that

It shall be the duty of all foremen to report any man late on the job to his employer at the time it occurs.

This rule appears to be commendable in its nature until it is explained that the union insists that, inasmuch as this is the only express stipulation of its kind in the rules, it therefore follows that the foreman can report only this infraction and no other to his employer.

A foreman in the Painters' Union is prohibited from commenting as to whether a man is doing a proper or improper amount of work.

The Plumbers' Union rules provide that no man may be employed as a superintendent who for any reason is in bad standing with the union, although the superintendent is not necessarily required to be a union man.

The electricians and the lathers both submitted demands January 1, last, requiring that on jobs employing three or more men a foreman shall be employed or at least one of the men should receive a foreman's pay.

Another matter which has been taken from the employers' control by the unions is that of selecting and employing

apprentices in the several trades. Young men desiring to learn a trade in former years were accustomed to apprentice themselves to an employer who undertook to train them and eventually fit them to serve as finished journeymen. This system some years ago became offensive to the unions because it was believed that too many journeymen were being educated for the welfare of the union. Also apprentices were used for many of the simpler duties to the exclusion of union journeymen. Therefore the unions ultimately insisted that apprentices should be furnished only through the unions.

Since this time many rules have been established by the unions regulating the selection, employment and work of apprentices. The general tendency has been to restrict greatly the allowable number of such apprentices and to select them with regard to their union proclivities and affiliations.

A tendency of recent years on the part of the unions has been to prescribe rules governing payment for all expense of travel when men are sent out of town and, in addition, all board and expenses. The time of reporting for and leaving work is also covered by a great variety of rules.

There are several rules which prohibit work being done in the most economical manner.

Thus, it is provided by the Plumbers' and Steamfitters' Unions that all piping up to 2½ inches in diameter must be cut *on the job by hand*. It would, of course, be very much cheaper to have all of the piping cut to exact measure in the shop, using power machines for the purpose, or even to cut it on the job using power, but this is absolutely prohibited by the rules of these unions.

The ornamental work in plastering was once cast in moulds at the shop and erected as units by the plasterers. Now the union requires that all of this work must be run in place by hand work.

Paint spraying machines have recently been invented which may be effectively used for painting flat surfaces. Government tests have demonstrated their efficiency and cheapness as compared with hand painting. The rules of the Painters' Union, however, prohibit their use.

The Painters' Union also prohibits the use of a brush more than 4½ inches wide in applying paint by hand.

The Plasterers' Tenders' Union specifies the particular size of hod it will use and also requires that no bag material shall weigh more than one hundred pounds.

The evident intention of the rules just referred to is to make work for more men regardless of economic considerations

Another group of rules is aimed to compel the use of high-priced skilled mechanics to do unskilled work which any intelligent laborer might do.

For example, plumbers must handle all plumbing materials after they have been delivered on the first floor. An employer might prefer to lift the bath tubs for the upper stories by means of a derrick, but the rules provide that they must be handled by plumbers.

Automatic electric pumps are frequently installed for permanent drainage of subways and deep basements, and are found to require only occasional inspection for oiling. On a construction job, however, such a pump requires the constant attention of a union engineer at $1.00 per hour.

Similarly, a small gasoline driven diaphragm pump of the type formerly operated by hand now requires a union engineer, although any intelligent water boy is competent to do the actual work required of him in addition to his other duties.

A steam operated derrick engine on a certain job properly required a hoisting engineer. An electrically driven concrete mixer on the same job did not necessarily require a skilled engineer, but employed one nevertheless. On the same job there were two other machines installed, a cable drum electrically operated for hauling charging cars and a small air compressor also electrically driven to furnish air for some jack hammers.

The union temporarily could not supply engineers for the two latter machines, but provided that the wages which would have been paid to an engineer on the compressor should be divided between the two members of the union

who were employed. Also it was directed that upon any day on which the cable drum was operated an additional two hours' pay should be allowed one of these men. No service was rendered by these men in connection with the operation of either machine but each man received twelve hours' pay for eight hours' work, and if the second machine was operated, one man was allowed fourteen hours' pay for his eight hours' work.

On one occasion the engineer employed to operate the concrete mixer wished to attend a meeting of his union on an evening when it was desired to run his machine. He arranged with the foreman of the concrete gang to look after his work in his absence. The mixer was operated until 9 P. M. and the following day this engineer claimed and subsequently received double time pay for the period during which the machine was operated while he was absent.

On another job two pile driver engines were employed, each operated by a union engineer. Two small electrically driven concrete mixers were in use at the same time and the only labor required to be done upon them was that of throwing in the switch to admit the electric current. This work was done by the concrete foreman. The union required that each engineer on the pile drivers be paid two hours extra each day, although neither engineer ever tended the apparatus in question.

The Carpenters' Union requires that all temporary work, such as erecting working stagings and the like, shall be done by union carpenters; also that the stripping of forms from concrete surfaces must be done by carpenters, although it has until very recently been done in a perfectly satisfactory manner by laborers.

All men employed on or around pile drivers and lighters which are engaged upon wharf building, except the engineers, must be union wharf builders, a branch of the Carpenters' Union. Many of these men do purely laboring work, but because of their rating draw skilled men's pay.

For several years after reinforced concrete work was introduced into this locality, the steel reinforcing bars used to

strengthen the concrete were handled and placed by common labor. Later it was provided in the rules of the Iron Workers' Union that all of this work should be done by members of that organization. A recent job in this locality was done by a non-union contractor using laborers to handle and place the reinforcing steel at a cost of $7 per ton. A similar union job going on at the same time required union iron workers for this purpose at a cost of $37 per ton.

Union iron workers must also be used to do any work in the nature of rigging, that is, the erecting, dismantling or operating of derricks (other than operating the engine); loading or unloading of machinery; erecting, moving or dismantling towers, chutes, etc. At the Army Base job there were used a large number of very light derricks hoisting small buckets out of the foundation excavations. The men actually used for signaling the engineer when to start and to stop were recruited from various walks in life, some being former street sweepers, some retired bar tenders, others having served as janitors, but all at that time rated under a union permit card as skilled union iron workers.

Stoves used at night for the drying out of plastering may not be looked after by the ordinary watchman but must be attended by a member of the Plasterers' Tenders' Union. Similarly, all dirt or debris made by a plasterer must be cleaned up by a union tender and not by unskilled labor.

Union plumbers must be used to lay even temporary piping used for construction purposes only, as well as the suction and discharge piping of pumps.

Union sprinkler fitters must be employed to lay underground cast iron pipes which conduct water to the sprinkler system; and union plumbers similarly must lay cast iron water pipes connecting with the building plumbing. Neither of these trades is as efficient as a trained laboring gang experienced in this class of work.

It must be apparent that the sole object of rules such as these is to provide work for the maximum number of members of the union in question, regardless of the economic effect upon the cost of the work.

There are numerous rules of a purely dictatorial character which serve to restrict the employer in the exercise of his natural functions.

As an illustration, the plumbers' rules provide that the employing plumber, or one of them if it is a firm, may do so-called jobbing work in the shop provided he does not do more than 50 per cent of all the jobbing to be done.

The Plasterers' Union rules provide as follows:

"The employer shall be allowed the privilege of closing his weekly payroll on Thursday night in the Greater Boston district."

A revised constitution of the Lathers' International Union adopted at the annual convention at Toledo in September of last year provides that "All locals shall have power to regulate the granting of permits to contracting lathers, provided:

"First. That the fee charged contractor or solicitor, shall be left to the discretion of each local, but not to exceed $100 and the resident limit cannot exceed one year."

The effect of this rule is actually to prohibit any contracting lather from doing business unless he first secures a permit from the union at not exceeding the sum of $100, which permit must be renewed yearly.

The Lathers' Union also contains a provision that men working less than four hours shall be entitled to at least four hours' pay and if more than four hours is worked the men must be paid at least eight hours' pay.

The Painters' Union requires that men shall not go to the shop for tools or material during the noon hour but may only do so during the working time. Similarly, the Lathers' Union provides that men shall not be shifted from one job to another during the noon hour.

Both Lathers' and Plasterers' Unions insist that when employers have occasion to do work within the jurisdiction of another local, 50 per cent of the men must be hired from that local.

The Lathers' Union specifies the particular kind of nails and staples which the employer must furnish.

The Hoisting Engineers' Union directs that men who report for duty shall be paid two hours' pay for reporting if not put to work, unless they have been notified at the end of the previous shift not to report. Thus, if it happens to be stormy in the morning so that no work can be done, the engineers must still be paid $2 for reporting. If an engineer is put to work at all on the day shift, he is entitled to at least four hours' pay and eight hours' pay if he starts to work on a night shift.

The engineer must be paid one hour's pay for getting up steam, which work he shall do unless the night watchman is also a licensed man, in which case the latter may get up steam for the engineer.

If any work is done on or with an engine during the absence of the regular engineer he must be paid just as if he had been present. In one case an engineer was requested by his employer to work on Saturday afternoon and Sunday in order to make some needed repairs on his engine so that the work would not be tied up on the following Monday. The engineer refused because of another engagement. Thereupon the employer hired some machinists from a nearby shop who made the desired repairs. The engineer subsequently made a claim for and received pay at double time rates for the period during which the machinists worked.

Some steel reinforcement was placed by union iron workers on a Saturday. On the following Sunday a gang of laborers was used to place concrete around the rods. The steel was found to be not in its correct position and so was taken out and replaced by the laborers. The iron workers subsequently demanded and received pay for the work as if they had been present.

A hoisting engineer can be used to operate only a particular machine. Even though his engine be temporarily idle he cannot be shifted to another, but a second man must be employed for this purpose. On one job some repairs were to be made upon a large grab bucket. Machinists were brought out on a Sunday to do the work. An occasional lift by means of a derrick was required for a few minutes at a time. An

engineer who was on duty looking after a pump was competent to do the necessary work, but he could not be used because the rules required that the regular engineer on the derrick was the only man who could touch the machine at any time. As a result, the regular man was used and paid at double time rate to make about six or eight lifts, while the other engineer was an interested spectator. Incidentally, it costs an engineer a $5 fine if he is caught breaking this rule.

A hoisting engineer not only must confine himself to his own machine but he must not furnish steam to a second unit unless he receives two hours' extra pay per day for so doing. Furthermore, not more than one extra machine can be attached to his boiler.

No engineer is permitted to take the place of a discharged engineer without first securing the permission of the business agent of the union.

The hoisting engineers' rules provide:

> In case of any misunderstanding between engineer and employer in regard to wages or conditions, engineers shall refer matter to Business Agent, whose decision shall be binding till next meeting of this union.

Practically all of the unions have adopted a rule that members must be paid off during working hours and are entitled to pay at overtime rates for all time while waiting for pay after hours.

The Cement Finishers' Union insists that the employer cannot hire his men direct but only through the union office. In this manner the men are kept under strict discipline, because they may be easily penalized by the business agent for any infraction of the rules or understandings by not being assigned to a job for a week or two. It is also possible to punish a contractor when deemed desirable by sending him the poorest men or by limiting the number of men he may use.

A contractor cannot choose which engineer he desires to keep when one or more machines are shut down. He must release the man whose engine is dispensed with even though this be his best man.

Engineers are not allowed to operate the water valve on a concrete machine, although the valve is purposely placed within easy reach of the operator of the machine. As a result the engineer must step aside each time the mixer is charged in order to allow a laborer to take his place for a few seconds and turn the water valve.

The Electricians' Union rules require that members working in the harbor shall be paid from time of leaving to return and in no case for less than a full day.

The minimum period for which an electrician may be paid is one-half day.

The 1921 demand of the Engineers' Union provides respecting overtime, that "an engineer shall receive not less than two hours' pay for any fraction of an hour's work."

The Stone Cutters' Union, in order to penalize any work done outside of its jurisdiction, provides that its rate of pay shall be five cents an hour more than the normal rate for work done on stone which has been partially worked elsewhere.

A certain wood carver paid his men the union rate and in addition gave them a bonus for all work over a definite amount. The union agent upon discovering this fact ordered the practice stopped upon the grounds that it served as too much of a spur to the men.

All rules, such as the preceding, are the natural consequence of the absolute power vested in the unions by reason of their monopoly of control over the industry.

One of the annoying and expensive features of trades unionism in the building industry is that pertaining to jurisdictional disputes. There are some twenty-seven separate trades unions which have to do with building work. Frequent questions arise between them as to which one is entitled to do certain work.

For instance, carpenters and iron workers quarrel over the question of which has the right to set steel sash and door frames.

The iron workers and steam fitters both claim the right to install pipe railings.

Electricians and elevator constructors disagree over the placing of certain devices in connection with electric controls.

Iron workers and metal lathers both claim the work of placing steel reinforcing.

Cement finishers and bricklayers each insist upon pointing around steel sash.

Stone cutters and cement finishers each claim the rubbing down of concrete surfaces.

During the construction of the Army Base a number of pumps known as pulsometers were used in connection with the foundation work. They required frequent relocating and each time they were moved it necessitated the use of two steamfitters to disconnect and reconnect the steam pipes; two plumbers to remove and replace the suction and discharge pipes; then iron workers (riggers) to hoist and lower the apparatus in the holes and an engineer to turn the steam valve. The engineer and a good laborer could have done all of the work required in much less time and in an equally satisfactory manner.

A certain hospital in this city had occasion to move its X-Ray machine to a new building. A specialist, who for twenty years had done nothing but erect such machines, was engaged to do the work. It so happened that a number of union electricians were employed at the time on the new building and they immediately demanded that the specialist cease work upon the X-Ray machine and that the work be turned over to them to do.

The specialist was thereupon discharged and the union men were directed to proceed with the installation. None of the union men was experienced with such work and from time to time they called upon the operator, a female nurse, to explain to them how the machine was assembled. Repeatedly work which was found to be wrong had to be undone and changed. Finally, being utterly unable to make the machine work, the union men called upon the specialist to advise them and he refused, whereupon the union men gave up the job, the specialist was again called in and the installation finally completed.

The usual period required by the specialist for such an installation was from three to four days. Altogether, between two and three weeks were required in this case.

In addition to the excessive cost involved, all patients requiring X-Ray treatment had to be sent to another hospital during this period.

Regardless of its merits or objections, the eight-hour work-day has, by more or less common consent, come to be recognized as definitely established. Such a limitation has seemed especially desirable in the case of indoor employment involving, as is frequently the case, poor light, bad ventilation and extremely close application.

The work of the building trades laborer is conducted, usually, in the open air under exceptionally good hygienic conditions, and it might reasonably be presumed that the length of the working period was a matter of less importance in this instance than in the former case.

Furthermore, the work of the building mechanic is not continuous, as is that of the factory worker, but is frequently interrupted by bad weather conditions and by lapses in employment, so that employees in this industry have many opportunities for rest and recuperation which are not open to the indoor worker. Nevertheless, the eight-hour work-day has been generally adopted in the building industry as an accepted and desirable limit and is universally insisted upon by all trades unions.

There are some reasons for believing that the labor leaders have not always been consistent in their attitude toward the eight-hour day; but however this may be, it has frequently been apparent that the workmen themselves have preferred a longer work-day, especially if it involved bonus pay in the form of overtime allowances.

During the war, because of the demand for excessive production, overtime work was general and accounted in large measure for the great increase of income enjoyed by labor during that period. After the signing of the armistice, however, the eight-hour day was re-established with the result that labor became very much dissatisfied and strikes on government work were frequent in protest against what was considered to be a reduction in pay.

It is a requirement of all union rules in the building indus-

try that work in excess of eight hours per day shall be paid for at double the standard rate. The philosophy of the labor men on this point is that more than eight hours' continuous occupation is destructive of the physical and mental well-being of the men and that, in order to prevent unscrupulous employers from exacting an excessive day's work from their employees, a penalty must be imposed which will deter them from exceeding the eight-hour period.

The amount of penalty for overtime work would be a matter of small concern to the employer were it not for the fact that it is practically impossible to avoid overtime work entirely without involving uneconomic consequences. Oftentimes it is necessary to carry the work to a certain point before stopping for the night, and if this point is not reached at the end of the eight-hour period, the work must be completed under penalty rates. Sometimes a small amount of preparatory work is required to be done after hours to permit the balance of the work going forward promptly the following day. Repairs to machinery must frequently be made after hours to prevent the interruption to the work which would result if they were made within the eight-hour period. For all such work the employer must pay two hours' pay for each hour actually worked.

If it were true that the unions desired only to discourage unnecessary overtime work, the result could be accomplished quite as readily by a penalty of 50 per cent additional pay as by the 100 per cent now imposed. No employer is likely to add 50 per cent or even 10 per cent to his labor cost unless it is an absolute necessity. As a matter of fact, the 100 per cent tax is really looked upon by the labor men as affording an opportunity for increased compensation, and hence the rate is deemed by them to be of considerable importance.

During the construction of the Army Base, which work was carried on day and night, the labor delegates frequently complained that some men were unduly favored by the superintendent through receiving a disproportionate share of overtime work.

A rule of the Electricians' Union reads as follows: "When

a contractor finds it necessary to work men overtime, men working on the job must have the preference."

It is the custom in cement finishing work for the men to spread and level off the mortar surfacing during the forenoon and to wait for it to set sufficiently before giving it the final trowelling later in the day. The mortar last spread is usually not ready for trowelling until late in the afternoon, so that overtime in a considerable amount is usually necessary to complete the day's work.

To meet this situation, there have been introduced certain ingredients known as accelerators, which hasten the setting of the cement and permit the final trowelling to proceed almost immediately. The local cement finishers' union has refused to use these accelerators because such use deprives its members of their overtime.

Some unions require that their men shall receive double pay for all work at night, even though they be employed on a regular night shift.

An electrician was required to watch a certain piece of electric apparatus which ran continuously on a certain construction job. He was in attendance from 5 P.M. to 5 A.M. seven nights a week and received, under the union rules, one hundred and sixty-eight hours' pay per week. His duties consisted in seeing that the apparatus was oiled occasionally and he sometimes was required to throw a switch.

During the labor shortage of the past two years, employers discovered that a plentiful supply could usually be obtained by increasing the daily working hours beyond that customary in the locality with the resultant increase of bonus on the excess over eight hours.

If labor leaders are sincere in their expressed desire to keep all jobs within the eight-hour limit, this could best be accomplished by reducing the overtime allowance to an amount which would look less attractive to their workmen and at the same time would operate to penalize the employer sufficiently to prevent its too frequent adoption.

The five-day week has now been adopted by five of the trades connected with the building industry. As a matter of

fact, the five-day week means the elimination of all work on Saturday, for even though the first five days of the week, or any of them, be stormy so as to prevent any work being done, the men are still prohibited from working on Saturday except under a special permit and then only at double time rates.

As long as the balance of the building trades work on Saturday forenoon, it is more or less necessary to utilize some of the men from the five-day trades in order to prevent interruption to the work. All such men must have the permission of their business agent and in addition must receive double time for the period worked on Saturday. Naturally, this situation creates a preferred class of workmen so far as Saturday work is concerned, and, in addition to the added cost to the employer, produces an atmosphere of dissatisfaction among the men of other trades who receive only single time for Saturday forenoon.

The cumulative result of the almost innumerable requirements of the unions as applied to the building industry in Boston today is an increased cost in construction of probably at least 25 per cent. In other words, the man who builds an $8,000 house pays $2,000 merely to satisfy the whims of the trades unions, and the sad feature of the matter is that no one benefits from this expenditure.

On the face of things, the unions assume that they are profiting through the payment of additional wages and the employment of a greater number of their members. As an actual fact, however, this increased cost of construction drives prospective builders out of the market, with the result that the total volume of work is greatly decreased and the average yearly income of the workman is reduced.

The advocates of the present union labor policy are apparently not intelligent enough to realize that for every owner who can afford to pay $20 per thousand for laying bricks, there are five or six other owners who could afford to pay $10 and who cannot build at all at the current rate. For each owner who can afford to pay $20,000 for a dwelling house, there are probably ten who would be willing to spend

$10,000 for the same purpose. An hourly rate of $1.50 as recently demanded by the unions would make it impossible for anyone to build except for the most urgent reasons, and it is altogether probable that the yearly income of the men would actually be less at this rate than would be received by them under a rate of fifty cents per hour.

The fact is that owners absolutely cannot build today, because at present costs the possible incomes to be obtained from the completed building will not pay the investment and upkeep charges. There are only two possible remedies for this situation: to increase rents materially or to reduce building costs by a substantial amount.

There are projects running in value into millions of dollars which could and would be under way in this locality now if building costs were reduced sufficiently to meet their income possibilities. Contrary to the prevailing notions of the labor unions, these buildings will not be built at present or further increased costs, and the result must be that millions of dollars which otherwise might be distributed in labor payrolls will not go into labor's pocket.

Building materials have made substantial recessions. Lumber, steel, cement, and many other commodities have suffered very material reductions in prices. It remains for labor to awake to its responsibilities and to eliminate every unnecessary and uneconomic practice which adds to cost.

But the labor advocate tells us that the real cause of high costs is the excessive profit charged by the contractor for his service. The answer to this argument is very simple. By the provisions of law the contractor operates in open competition with all comers. Anyone, labor men included, may enter the business at any time and secure these excessive profits for themselves if they exist. Nor is it absolutely essential that they possess any great amount of capital. I have known of many contractors who began business with practically no money, but whose credit was good because of their reputation for honesty, ability in their line, and their general knowledge of their trade. No union card is required nor is anyone's permission necessary for any person to be-

come a contractor. Most contractors would welcome a condition under which labor would put its services upon the same basis and allow each member to derive his income in unrestricted competition with his fellows, as must the contractor.

Government statistics tell us that 75 per cent of the men who enter business in the country fail, and the building business is rated as one of the most hazardous of business callings.

Undoubtedly a majority of employers would appreciate the opportunity to combine and agree upon their prices as do the members of labor unions. This, as already stated, is forbidden them and organized labor has always been loudest in condemnation of any such suggestion. It would seem, therefore, that no valid criticism can be directed against the occasional employer who succeeds in spite of these handicaps.

It might quite naturally be assumed that the increased pay, shorter hours and lessened unit production which union conditions have brought about, would be greatly appreciated by the workmen so benefited. It has been my observation, however, that this is not the case. Leaders of organized labor have diligently and continuously attempted to educate their members to the belief that they are being denied their rightful share of the profits of industry; that they are discriminated against in the application of the laws and that society in general is ungrateful and unresponsive for the superior benefits conferred upon it by labor.

As a result of this effective schooling, labor is more unhappy and more dissatisfied with its lot today than at any previous time in its history. Personal initiative and individual pride of accomplishment have been almost completely destroyed by placing all men upon an equal basis of pay and of output. In addition, there has gradually come the disagreeable realization that with increased compensation and reduced output there must necessarily also ensue higher costs for commodities and a commensurate advance in the cost of living, thereby leaving the workman no better off and frequently in a worse state than before. It cannot fairly

be said that such a result from the activities of any organization is indicative of a beneficent institution.

Organized labor has always insisted that its interests are naturally antagonistic to those of the employer and this impression has very largely prevailed in the minds of the general public. Just why this assumption has been so readily adopted it is difficult for me to understand. Unless the employer is prosperous, it must be evident that his employees cannot prosper. That which makes for an increased volume of work benefits both classes, and that which restricts the amount of work which can be undertaken similarly does injury to both. It would seem to follow that the true interests of both groups lie along parallel lines.

If membership in a trades union could be made a guarantee to the employer and public alike of superior skill, efficiency, fidelity and co-operation on the part of each of its members, no intelligent employer could afford to deal with any other body of workmen even though the rates of pay were correspondingly greater for union employees.

When an employer resists demands of the union which tend to lower efficiency and to increase costs, he is working for the union's interest quite as much as for his own, for such practices inevitably reduce the volume of work and thus penalize both.

It has recently become popular on the part of labor unions to demand what is referred to as a living wage. As I understand the term, it is intended to represent the amount of income which will allow the recipient at current prices to enjoy the standard of living which he has established as desirable for his comfort. At the present time this so-called living wage is variously estimated at from $2,000 to $3,000 per year.

Apparently in the establishment of these figures no consideration has been given to the gross amount of wealth which is available for distribution as income. Obviously, if nothing was produced in the world, there could be no income for anybody. The greater the total production, the greater the average income becomes. Let us see what the actual figures are.

The report of the Internal Revenue Collector's Department for the year 1918 indicates that there were 1,832,000 persons in this country whose incomes for that year were in excess of $2,000, and the total income received by this class was $11,191,000,000. Assuming five members to the average family, there would be approximately 22,000,000 families to be supported. If all of the excess incomes over $2,000 were to be confiscated and divided among the remaining families, each family would receive about $374. Furthermore, the returns indicate that there were some 18,000,000 families receiving less than $1,000. This leaves 2,168,000 families with incomes between $1,000 and $2,000. Assume that the 18,000,000 families all received as much as $1,000 and that the 2,168,000 families averaged to receive $1,500, we would then have a total income for the entire country of $32,443,000,000. Divide this figure by 22,000,000 and we find the average income to be approximately $1,500 per family per year. These figures indicate conclusively that present production would have to be doubled to permit an average income of $3,000 per family in this country.

The labor leader or sympathizer who demands an increased wage combined with a decreased production is advocating an economic paradox.

During the past four or five years we have experienced in this country an era apparently of exceptional prosperity. So great has the demand for all classes of labor and commodities been that wages and business profits generally advanced to unprecedented high level. The money which we paid for this labor and for the commodities was in part the accumulated surplus wealth of the countries of the world but was principally derived from the hundreds of billions of borrowed wealth which still requires to be repaid. By far the greater proportion of this money was not paid out for commodities or labor which permanently enriched the world's resources, but rather was contributed to the waste of war or for extravagancies and luxuries which were of only passing value. As a result, the world's wealth has been greatly decreased and an enormous debt accumulated. It is as if the individual

had squandered his personal savings and in addition had exhausted his borrowing credit, with no resulting assets with which to discharge his debts.

This great world debt has to be paid. It can be paid only by the individuals who people the earth. Each of us in the last analysis must pay our share. Those who possess money may contribute in the form of taxes. Those who have no money will contribute either in the form of additional labor or of a reduced standard of living. But no one can possibly escape his share. For any person or any group to argue that they are permanently entitled to the same (or a better) net income as they received before the war, is to argue that they should be relieved from payment of their share of this world debt.

Organized labor has shown no disposition to recognize these economic truths or to admit its responsibility for assisting in the rehabilitation of normal conditions.

Thinking people in all walks of life are awakening to a realization that the days of luxury and easy incomes which have prevailed for the last few years are now a thing of the past, and that unless world bankruptcy and economic chaos are to follow we must buckle down as never before to produce cheaply by eliminating all waste in industry and to avoid all unnecessary extravagancies in living until such time as our enormous debts have been discharged. By this means only can normal conditions again be established.

If organized labor refuses to co-operate with the balance of society in bringing these conditions about, then we must go along without it.

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CONSTRUCTION COSTS.

By W. N. Connor.*

(Presented February 16, 1921.)

Introduction.

There have been many books, pamphlets and papers published on cost accounting, but very few dealing with its application to construction work. One reason for this is that so few contractors keep a thoroughly accurate check on their costs or maintain a standard cost system. A majority rely on their bookkeeping department to furnish them cost data. This, to my mind, is doubtful practice, as a bookkeeper deals in absolutely accurate figures down to a penny, while the cost accountant's viewpoint is somewhat more liberal.

I do not mean by this that the cost accountant's figures need not check with the bookkeeper's ledger, for they must; but the training of the bookkeeper is such that he will naturally figure his costs in the same manner as he keeps his accounts, and thereby often lose the sense of proportion of costs. Costs are really tied up just as closely with the engineering and estimating departments as with the accounting department. The cost accountant should understand the physical side and be able to visualize the work itself — a thing which a bookkeeper is not trained to do.

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In the introduction to the book "How to Find Factory Costs," by C. B. Thompson, occurs the following:

"The Federal Trade Commission has called attention to the fact that less than 20 per cent. of the business concerns in this country have a cost system, and that a large proportion of the many failures recorded every year is due to the absence of an accurate knowledge of what it costs to manufacture and sell. The Commission is urging every business man to take this first step in the development of that primary effectiveness by means of which alone this country can be brought to an appropriate degree of industrial preparedness."

Mr. Thompson also says:

"The chief distinction between financial accounting and cost accounting is that the former deals exclusively with the money and credit transactions of a business, while the latter deals with these same transactions but with reference to the cost of products and operations. The unit of financial accounting is the unit of money, whether the dollar, the pound, or the franc, while the units of cost accounting are the units of *money plus the units of operations*, of sales, of product and of time."

The three functions of any cost accounting system are:

1. To aid in assuring the economical handling of the work while it is in progress.

2. To obtain figures to compare with the estimate.

3. To supply data for use in estimating future work.

These are given in order of their importance.

Costs must be available at once to be effective in aiding economical handling of the work. Delayed reports of costs are practically useless in effecting any savings while the work is in progress. Proper cost reports have been compared to a fire-alarm system, in that they should not alone be able to give notice of some unusual condition but equally lead the investigation to the seat of the trouble.

Each morning the labor costs of the previous day should be known. This is not necessary or feasible on all items of work, but on such as concrete, excavation, brickwork, etc., it is possible and extremely important that the superintendent of a job should know the daily labor unit costs. If he has them he can take up with the foremen at once any variations between estimates and

actual performance, and endeavor to equalize disproportionate costs of any unit before it is too late. Prompt cost reports enable him to comment intelligently on various items before they become past history, and to be certain that both he and his foremen understand just what constitutes matters of major importance from the costs standpoint.

Only the direct labor on any operation should be included in these cost figures: that is, plant, overhead, etc., should be reported separately and not included with the direct labor charges.

By regular comparison between the actual costs obtained and the estimate, and by means of comparative statements made weekly and monthly, overruns or savings on the estimate may be discussed with the owner at once and he may be kept informed as to just how the job stands financially. This is particularly important on percentage work, as it permits the contractor and the owner to get together and talk over the progress of costs, and, if necessary, to make intelligent changes of plan while the work is under complete control and the financial bearing of changes is understood.

It used to be the custom, and I'm afraid it is yet in a good many companies, to regard costs as something to be kept secret and locked up tight, never letting the foreman know what his costs were, but always suggesting that they were excessive. How can a man be held responsible for his costs unless he is given full information regarding them while his work is in progress? And what makes for better work and loyalty then telling a man when his costs are good and commending him for the fact?

A few years ago a paper was read before this Society entitled, "Cost Accounting on Construction Work." This well-written pamphlet explained fully the system then used by the Aberthaw Construction Company for keeping costs. Since then, some changes have been made, the principal ones consisting of a change of forms, the placing of actual tabulating of the costs with the job, and the establishing of a separate cost accounting department, where before cost accounting had been a function of the estimating department.

It is difficult to make a paper interesting in which one is dealing almost entirely with figures, and I have decided that perhaps the best method is to show the various forms and explain their use and functions.

It is my intention to start with the making of an estimate and to follow through the various steps taken with an explanation of the forms used to record these cost data. I shall take up, first, the labor costs.

Section I.

LABOR COSTS.

1. *Summary of Estimate.*

At the start of a job an estimate is made in the usual manner. This shows the actual take-off from the plans, with the items, quantities, units and amounts. These units include the labor, material, overhead and plant costs.

FORM 1.

ABERTHAW CONSTRUCTION COMPANY, BOSTON.

Job No. 1175. November 4, 1919.

SUMMARY OF ESTIMATE.

MFG. BUILDING, TORRINGTON MANUFACTURING CO., TORRINGTON, CONN.

Concrete:			
Footings, 6+13	19 c. y.	$11.00	$209
Footings, 73+126	199 c. y.	12.75	2 540
Columns, 101+29+50+13+27	220 c. y.	12.75	2 795
Stairs	464 f. l.	1.50	696
Paving	748 s. f.	.22	165
Carbo. rub	8 000 s. f.	.08	640
Forms:			
Exterior and interior footings	2 886 s f	.19½	563
Walls below grade	4 828 s. f.	.19½	990
Exterior columns	9 417 s. f.	.22½	2 120
Interior columns, metal forms	48 #	21.00	1 005
Floor and roof slab	32 042 s. f.	.17	5 450
Wall beams	4 212 s. f.	.23	970
Interior floor beams	967 s. f.	.23	222

Reinforcement	110 ton	100.00	11 000
Spirals	1 ton	120.00	120
Excavation:			
Wall footings and int.	660 c. y.	2.00	1 320
Backfill:			
Cinders	75 c. y.	2.50	188
Earth around footings	600 c. y.	.60	360
Steel windows:			
Sash, including glazing	6 300 s. f.	.69	4 342
Masonry			
Ter.a-cotta partitions			
4-in. plaster d both sides	5 400 s. f.	.50	2 700
6-in. {Plastered one side / St cco one side}	413 . f.	.65	268
Carpentry:			
Laying floor on tar rok	74 sqs.	8.00	592
2-in. spruce plank	16M	100.00	1 600
1-in. maple or spruce	9½M	90.00	855
Laying same	74 sqs.	.25	240
Roof over platform	250 s. f.	.50	125
Roofing:			
Laying tar paper	10 800 s. f.	.03	324
3-ply tar and gravel	108 sqs.	13.00	1 405
3-ply tar and gravel	2½ sqs.	11.00	28
Toncan metal bases and cap flashing	500 f. l.	.45	225
4-in. conductor boxes	5 #	20.00	100
Galvanized iron gutter	23 f. '.	1.50	35
Flooring:			
Mastic floor	1 140 s. f.	.45	514

Quantities by R. L. A. Extension by R. L. A. Checked by R. L. A.

2. *Analysis of Estimate — Labor.*

This estimate is then split into a labor and a material analysis. In the labor analysis these various items will show only the direct labor, with plant labor and overhead separated.

Opposite each item in the labor analysis is shown the symbol under which the working time is to be reported. This analysis is sent to the job, where it becomes the standard for labor cost comparisons on all operations of the job, and the estimate is not referred to.

One can readily see that, by separating labor and material, the work for the job superintendent in following his costs has been made much easier. He knows by the labor analysis just

what figure the Estimating Department has set for the unit on each item. He is able to study his labor costs without being obliged to figure out his material, for the cost of which he is very often not responsible, as a great deal of the purchasing may have been done at the home office. He has condensed for him now those units for which he is responsible. If he thinks any of them too low, he can take up the case at once with the Estimating Department — and I must confess that this is done quite often.

FORM II.

ABERTHAW CONSTRUCTION COMPANY.

Job No. 1175. January 8, 1920.

ANALYSIS OF ESTIMATE.

LABOR.

Code					
	EXCAVATION.				
Di	Pumping				$200
Das	Clear site				100
Dad	Excavate for footings	800 c. y.		$1.70	1 360
	PLANT				
Pel	Towers and hoists 415				
Pen	Temporary buildings 415				
Pem	Mixer, motor and pits 205				
F Pes	Sawmill 130				
Per	Access runs and staging 250				1 895
Pe	Miscellaneous plant 130				75T
Pu-T	Teaming plant 75T				
Pu	Unload 245				
Peb	Boiler and shack 105				
	FORMS.				
Fac	Exterior columns Make	31 sqs.		4.95	154
Fec	Erect	62 sqs.		10.65	660
Fic	Strip	62 sqs.		2.30	143
Fawb	Wall beams and pilastered Make	20 sqs.		3.20	64
Fewb	parapet Erect	42 sqs.		12.50	525
Fiwb	Strip	42 sqs.		2.30	97
	STEEL.				
Ru	Unload reinforcement	114 tons		2.30	262
Ru-T	Team	114 tons		.55	63T
Rac	Cut and bend col. steel	27 tons		3.55	96
Rec	Place col. steel	30 tons		8.55	257

CONCRETE. — Mix and Place.

Med	Footings, piers and pipe supports	306 c. y.	1.45	444
Mep	Paving	12 c. y.	1.80	22
Mef	Exterior and interior columns, floor and roof slabs, wall beams and interior floor beams, including patch and first rub	1 020 c. y.	2.05	2 095
Mecw	Curtain walls	100 c. y.	6.70	670
Mux	Unload and handle cement	3 400 bbls.	.16	544
Mux-T	Team cement	3 400 bbls.	.11	374T
Muy	Trim sand stock pile	850 c. y.	.085	72
Muz	Trim stone stock pile	2 020 tons	.085	172

OTHER TRADES.

Sew	Set and point steel sash	6 800 s. f.	.62	422
Tef	Lay Tar Rok floor 1 in. thick	76 sqs.	4.40	334
Ced	Setting doors and hardware	# 26	9.75	253
Glew	Glazing sash	3 200 lts.	.0975	312
W	Watchman			500
O	Job overhead			1 700
Mh	Cold weather expense			2 500

3. *Timekeeping Symbols.*

Most contractors use a series of numbers for reporting their labor operations, but Aberthaw uses a mnenomic code.

In the Aberthaw system the first letter is always a capital and indicates the kind of work to be done. For instance, —

F stands for Forms,
R for Reinforcement,
B for Brick,
D for Digging, etc.,

in so far as possible the first letter of the item represented being used. The second letter is always a vowel and explains the class of the work.

a stands for making items,
e for erecting or setting up,
i for tearing down or dismantling,
o for repairing,
u for unloading.

The third letter, which is always a consonant, indicates the part of the building in which the work is being executed, as —

f floor,
w walls,
c columns,
s stairs.

As the code is the same on all jobs, our timekeepers and cost men quickly adapt themselves to any requirements of the work. If some work comes up not included in the code, a timekeeper can very quickly make up his symbol to cover it, and it can usually be interpreted by the cost man. If necessary, an explanation may be written opposite the item the first time it is reported.

A real feature of this code is the manner in which it helps visualize the work. For instance, with numbers one might have 21.1 as a symbol for erecting brick walls. How much better is the symbol Bew, — " B " brick, " e " erect, " w " walls.

FORM III.

STANDARD SYMBOLS

Flat Slab	Make	Erect	Strip	Report
Floor and roof slab panels, wood	Fafw	Fefw	Fif	Square feet
Floor and roof slab girts	Fafg	Fafg	Fif	Lineal feet
Floor and roof slab joists	Fafj	Fefj	Fif	Lineal feet
Floor and roof slab panels, metal	Fafm	Fefm	Fifm	Square feet
Plinths	Fafp	Fefp	Fifp	No. and sq. feet
Floor and roof slab mud sills	Fafs	Fefs	Fif	Lineal feet
Floor and roof slab posts	Fafv	Fefv	Fif	Number
Flat slab, inclusive	Faf	Fef	Fif	Square feet
Beam and Girder				
Floor beams and panels, inclusive	Fafb	Fefb	Fifb	Square feet
Gutters and open drains	Fag	Feg	Fig	Square feet
Cornice, coping and belt course	Fak	Fek	Fik	Lineal feet
Stairs	Fas	Fes	Fis	Lin. ft. of stairs and sq. ft. of landings.
Tunnel walls and ceilings	Fat	Fet	Fit	Square feet
Walls	Faw	Few	Fiw	Square feet
Walls erected between slabs, columns or walls previously poured	Fawp	Fewp	Fiwp	Square feet

Wall beams, erected with slabs and columns . . . . . **Fawb** **Fewb** **Fiwb** Square feet

Threading and rethreading bolts to be charged to "e" symbol on which used.

4. *Timekeeper's Field Sheet.*

To report the time and distribution of the men, the timekeeper uses a field sheet which shows each man's number in the left-hand column.

These sheets are in two series, one running from 0 to 50, and the other from 51 to 100, and the numbers are printed on the sheets, so that if a job has a series of checks numbered from 1 200 on, the timekeeper needs only to write in the number 12. The next columns show the time at which the men reported for work and the time at which they quit work.

Then there are eleven columns, each one representing one hour's work, and headed 7–8, 8–9, 9–10, etc., up to 5–6. In these spaces, after each man's number is written the symbol for the type of work performed. If one man is erecting forms from 7 to 12 continuously, the symbol "Fef" would appear in the first hour column and a dash in each succeeding column up to 12 o'clock. Then he might change and work at erecting wall forms to 5 o'clock. In such case the symbol "Few" would show. The timekeeper makes four checks a day, and if the men have changed their class of work between checks, he confers with their foremen as to the hour when changes have been made. The remaining columns show the rate, then the amount earned and the actual hours worked divided into regular and overtime.

We have, therefore, on this timekeeper's field sheet a complete record of each man's daily time and class of work performed.

This field sheet is the same length and ruled the same as is the pay-roll sheet. We can, therefore, in transferring the time from this field sheet to our pay roll, simply lay it down on the pay-roll sheet and copy the figures on the lines which coincide. This offers a great saving of time and is much more accurate than calling the time off, or transferring it by comparing the men's numbers.

The type of ruling on forms is a very important item. Those forms which are to be used together should be, in so far as

FORM IV.

ABERTHAW CONSTRUCTION COMPANY.

Job No. 1175. TIMEKEEPER'S FIELD SHEET. Date, 12-27-19.

AT TORRINGTON, CONN. Timekeeper's Name, H. W. Murdick. Sheet No. 1.

MAN'S NO.		IN A.M.	IN P.M.	OUT.	7 — 8.	— 9.	— 10.	— 11.	— 12.	1 P.M.	— 2.	— 3.	— 4.	— 5.	— 6.	RATE.	AMOUNT.	TIME. Reg.	TIME. Over.
	2201																		
Kinsley	02	7	..	5	0	..	....	....	....	....	....	....	....	..	..	$39.00	$6.50	9	
	03																		
	04																		
Hollen	05	7	..	5	Raf	..	....	Raz	....	....	Ref	....	Rec	..	..	40.00	6.67	9	
Howard	06	7	..	5	Fec	..	Fed	....	Fedw	....	....	Fewb	....	..	..	48.00	8.00	9	
	07																		
Murdick	08	7	..	5	0	..	....	....	....	....	....	....	....	..	..	21.00	3.50	9	
	09																		
	2210																		
Zavrello	11	7	..	5	Dad	..	....	Mux	....	....	Mef	....	Ded	..	..	39.00	6.50	9	
	12																		
	13																		
	14	7	..	5	Fec	..	Fewb	....	....	..	Fedw	....	....	..	..	.85	7.65	9	
	15	7	..	5	Fef	..	....	....	....	....	....	....	....	..	..	.85	7.65	9	
	16	7	..	5	Fec	..	Fewb	....	....	....	Fedw	....	....	..	..	.85	7.65	9	
	17	7	..	5	Fef	..	....	....	....	....	....	....	....	..	..	.85	7.65	9	
	18	7	..	5	Fec	..	....	....	....	....	Fed	....	....	..	..	.85	7.65	9	
	19	7	..	5	Fec	..	....	....	....	....	Fed	....	....	..	..	.85	7.65	9	
	2220																		
	21	7	..	5	Raz	..	....	....	Ref	....	....	....	....	..	..	.55	4.95	9	
	22	7	..	5	Raz	..	....	....	Ref	....	....	....	....	..	..	.55	4.95	9	
	23	7	..	5	Rec	..	Raf	....	....	....	Ref	....	....	..	..	.55	4.95	9	
	24	7	..	5	Rec	..	Ref	....	....	....	....	....	....	..	..	.55	4.95	9	
	25																		

26	7	..	5	Mef	..	....	Ref	....	..	....	Mh	..	..	..	.70	6.30	9
27	7	..	5	Pel	..	Pem	...	....	..	Mh	....	..	..	..	.70	6.30	9
28	7	..	5	Mh	..	....	....	....	..	....	....	..	..	..	.70	6.30	9
29																	
2230																	
31																	
32	7	..	5	Mux	..	....	...	Muy	....	....	....	....	..	..	.50	4.50	9
33	7	..	5	Mux	..	....	Mef	....	....	....	....	....	..	..	.50	4.50	9
34	7	..	5	Mux	..	....	Mef	....	....	....	....	....	..	..	.50	4.50	9
35	7	..	5	Mux	..	....	...	Muy	....	....	....	....	..	..	.50	4.50	9
36	..	1	5	....	..	....	...	....	....	Mef	....	....	..	..	.50	2.00	4
37	7	..	5	Dad	..	....	Mef	....	....	....	....	....	..	..	.50	4.50	9
38	7	..	5	Dad	..	....	Ded	....	....	....	....	....	..	..	.50	4.50	9
39	7	..	5	Dad	..	....	Ded	....	....	....	....	....	..	..	.50	4.50	9
2240																	
41																	
42																	
43																	
44																	
45																	
46																	
47																	
48																	
49																	
2250																	
																$149.27	229

possible, ruled similarly. This fact I do not believe is usually given the emphasis that it deserves.

5. *Waste Sheet.*

The office cost man, with the timekeeper's field sheets before him, now uses a sheet which is called a "Waste Sheet." He combines all the "Fef," "Med," "Ref," etc., symbols of the Field Sheet and figures the total daily expenditure under each symbol. These amounts he enters each in a column headed with its proper symbol. The total should check with the total daily pay roll.

This sheet is ruled for seven days. It is kept up to date daily, so that at the end of the week the cost man has the total weekly expenditure for all the symbols under which work has been performed. The quantity man gives him the quantity of work accomplished, which he enters under the total weekly cost of the "Waste Sheet" and then figures the unit cost and writes that under the quantity. He then has under each symbol the total weekly expenditure, weekly quantity, and weekly unit.

6. *Labor Cost Record.*

The next step is to transfer these items to the Unit Cost Record Book. This is a loose-leaf, I. P. ring binder, carrying a sheet for each symbol. The first column of the sheet shows the date of the week ending; the second the weekly cost, the third the weekly quantity, and fourth the weekly unit. These items take up about one half the sheet. The other half shows the cost to date, quantity to date, and unit to date. As a partial check on these items there are included two columns, one for number of barrels of cement used, and one for cubic feet of concrete per barrel. At the top of the sheet, directly over the quantity, amount and unit to date column, is a space to write in the estimated quantity, amount and unit, so that these estimated figures can be compared with the actual figures at any time.

This is kept up to date each week, and is checked against the total pay roll of the job. This book is the permanent record of the labor costs and is sent to the home office at the completion of the job.

FORM V

Job No 1175 — WASTE SHEET — Week Ending 1-6-20

Date	Dao	Daop	Dedp		Fec	Fic	Fecw	Fecw	Fao	Fed	Fer	Fie	Ferb	Fewb	Fiwb		Gew			
12-31-19	10 35	77 90			30.00	12.00		8 40		17 95	74 95	32.80		12 48	8 25		8 50			
1-1-20		35 55	7 40		32 85	15 45		7 65			82 10	31 50	14.50	14 50	12 00		8 50			
1-2-20		59 20	9.00		27 50	17 20		9.20			78 80	31.99		12.00	10.30		10 30			
1-3-20	6.00	60 63			30 42	14 85	7 35	6 85			69 03	33 60		11 05	5 75		9 75			
1-4-20																				
1-5-20		75 85	5.40		27 58	19 00		5.00			80 15	29 00		9 00	8 25		9 75			
1-6-20		61 00			26.00	12 60		6 45	10.25		80.00	32 10		17 50	1 00		6.38			
Total	16 35	390.13	21.80		174 35	91.10	7.35	43 55	10.25	17.95	465 03	190 19	14.50	76.53	45 55		53 08			
Quantity	8cy	240cy.	6Icy.		16.25sq	25.6sq	1.25sq	4.25sq	1.9sq	1.9sq	90.5sq	70.7sq	4.7sq	7.4sq	15.7sq		220.5y			
Unit	2.03	1.63	.36		10.75	3.57	6.15	10.25	5.51	9.65	5.14	2.69	3.10	10.30	2 90		.24			

Date	Mecw	Med	Mef	Mh	Muy		O		Pe	Pel		Rac	Rec	Raf	Ref		Sefd	Sev		Total
12-31-19		4 10	141.61	50 30			15.41		7 70	3.50		5 06	11.45	8.40	27.43			15 60		583 24
1-1-20	18 50	3 00	168.14	54 90			15 41			8 00		4 23	12.16	9 23	31 80		9 75			617.12
1-2-20	9 00	4 60	176 33	53 10	11.00		15.41			2.00		5 73	9 81	8 80	24 10					585.17
1-3-20	2.50	1.55	86.64	48.60			15.41			2 00		7 10	10.42	10 15	29.48			6.29		474.82
1-4-20																				
1-5-20		4 60	93 22	61 33			15.41			1.00		3 10	8 63	9.41	32 46		11.40			509.54
1-6-20			40.72	62 65			15.41					2 20	15 60	7 26	15 33					412.45
Total	30.00	17 85	705 96	330 88	11.00		92.46		7 70	16 50		27 42	68 07	53 25	160 60		21.15	21.89		3182 34
Quantity	14c.y.	7c.y.	218c.y.		98cy							8 T.	9 T.	11 T.	18 T.			700 #		
Unit	2 14	2 55	3 24		.112							3 43	7 56	4 84	8 92			031		

Payroll w/e 1-6-20 @ 3182 34

FORM VI.

Form 57. 1-21-20

ABERTHAW CONSTRUCTION COMPANY

LABOR COST RECORD

SYMBOL Med

JOB NO. 1175

ESTIMATED

COST	QUANTITY	UNIT
$444 00	306 c.y.	1.45

ITEM Concrete Footings & Piers

Week Ending	Weekly Cost		Weekly Quantity	Weekly Unit	Total Cost		Quantity To Date	Unit To Date	Bbls. Cement	Cu. Ft. Per Bbl.
11-25-19	117	90	117 c.y	1.01					194	16.3
12-2-19	251	96	120 "	2.10	369	86	237 c.y.	1.56	198	16.3
12-9-19	72	27	42 "	1.72	442	13	279 "	1.23	69	16.4
12-16-19	9	97	6 "	1.66	452	10	285 "	1.59	10	16.2
1-6-20	17	85	7 "	2.55	469	95	292 "	1.61	12	15.7
1-13-20	4	86	2 "	2.43	474	81	294 "	1.62	4	13.5
1-20-20	12	70	10 "	1.27	487	51	304 "	1.60	17	15.8

7. *Labor Cost Statement.*

We are now ready to make out the Weekly Labor Cost Statement. In this, first the symbol is shown, then the kind of work; next, the weekly cost and weekly unit. Succeeding columns offer a detailed comparison with the Analysis of Estimate, — the estimated quantity unit and cost being set against the actual quantity and unit and cost attained in operation. The last two columns give opposite each item, in one case, the overrun; in the other, the saving.

As an illustration:

Suppose we have listed in our analysis of estimate 1 000 cu. yds. of concrete under the symbol " Med," at a unit cost of $1.50 per cu. yd. By the fifth week of the job there has been completed 700 cu. yds. at a unit cost of $2.00 per cu. yd. Seven hundred cubic yards at $1.50 would be $1 050, which would have been the expenditure on that item, provided the work had been done at the estimated unit of $1.50. But actual cost is $2.00 per cu. yd., which means an expenditure of $1 400, or an overrun of $350 on this item. If it had been done for a unit of $1.00, there would have been a saving of 50 cents per cu. yd., or a total saving to date of $350. Each item is figured out similarly, and the difference between the saving and overrun is shown in the proper column.

For those items on which no quantity is reported, as plant, watchman, overhead, etc., a percentage is used. For example, if $1 000 is allowed for overhead and the job is to last ten weeks, this overhead will average $100 per week. If, after the job has gone six weeks and $700 has been expended, and it is figured that $450 more will be expended, the overrun will be $150; and this is shown.

The labor cost sheet gives the costs in detail for the job superintendent to study, and informs him just where he should concentrate and what he should study. If 75 per cent. of his total overrun is in two items, the place for him to remedy his high units is clear. Without some such data how can a superintendent intelligently talk to his foremen or know his job?

FORM VII.

ABERTHAW CONSTRUCTION COMPANY.

AT TORRINGTON, CONN.

Job No. 1175. Sheet No. 1.

LABOR STATEMENT TO DECEMBER 23, 1919. — 8TH WEEK.

	Item.		Quantity.		Unit.		Cost.		Saving.	Overrun.
			Estimate.	Actual.	Estimate.	Actual.	Estimate.	Actual.		
	Excavation.									
Das	Clear site	$	100	.....	.....	.....	83	83		
Dad	Dig footings	c. y.	800	702	1.70	1.35	1 193	948		
Ded	Backfill around footings and walls	c. y.	950	331	.83	.54	275	179	683	
Dadp	Dig for pipe and conduit trenches	c. y.	1 030	931	1.70	1.48	1 583	1 378		
Dedp	Backfill pipe and conduit trenches	c. y.	980	442	.83	.52	367	230		
							3 501	2 818		
	Plant.									
Pe	All plant	$	1 895	.....	.....	.....	1 137	1 379		242
	Forms.									
Fed	Footings and conduit supports	sq.	39	36	10.50	8.91	378	321		
Fadw	Piers below first floor and walls	sq.	52	52.7	2.65	3.84	140	202		
Fedw	Piers below first floor and walls	sq.	78	78.7	10.50	9.77	826	769		
Fidw	Piers below first floor and walls	sq.	78	30.2	3.15	2.79	95	84		19
Faf	Floor and roof slabs	sq.	110	74	2.75	3.46	204	209		
Fef	Floor and roof slabs	sq.	320	41	5.50	7.73	225	317		
Ful	Unload and handle form lumber	M	96	47	2.30	1.98	108	93		
							1 976	1 995		
	Reinforcement.									
Raz	Cut and bend miscellaneous steel	t.	26	16	4.10	11.22	66	180		136
Rez	Place miscellaneous steel	t.	26	14	14.10	15.64	197	219		
							263	399		

	CONCRETE.									
Med	Footings and piers	c. y.	306	285	1.45	1.59	413	453	9	
Mux	Unload and handle cement	bbl.	3 400	3 147	.16	.14	504	441		
Mux-T	Team cement	bbl.	3 400	3 147	.11	.10	346	315		
Muy	Unload and handle sand	c. y.	850	415	.085	.12	35	50		
Muz	Unload and handle stone	t.	2 020	1 208	.085	.09	103	109		
Muz-T	Team stone	t.	2 020	1 208	.02	.04	24	48		
							1 425	1 416		
	MISCELLANEOUS.									
Sez	Miscellaneous iron work	$	400	.....	.....	.....	147	147	81	
Mh	Cold weather expense	$	2 500	.....	.....	.....	295	295		
O	Overhead	$	1 700	.....	.....	.....	592	511		
							1 034	953		
	Saving $376									
							9 336	8 960	773	.397
	Pay roll to date $8 597									
	Teams to date 363									
	Total to date $8 960									

8. *Labor Comparison.*

In order to condense this report for the management, a comparison of savings and overruns is made, listed under the various symbols. All the overruns or savings on one class of work are totaled, and the total overrun or saving shown as concrete, forms, reinforcement, etc. The record of the previous week is also shown so it may be compared with that of the current week.

The Labor Cost Statement, together with this labor comparison sheet attached, is sent into the main office each week so as to reach there not later than the Monday morning following the closing of the pay roll. One copy goes to the general superintendent and one to the Cost Department.

9. *Pay-Roll Sheet.*

The pay-roll sheet is ruled for seven days, with two columns for each day, — one to show regular and the other overtime hours. The regular and overtime hours are extended and shown in separate total columns, as also is the regular and overtime rate, the total amount earned for the week being in the next column.

The man's name and number appear in the extreme right-hand column. This, I think, is rather unusual, but we find it much better when paying off, as the person paying need only look at the next column and not from one side of the sheet to the other to check the name and amount, which lessens the danger of errors considerably.

So much for the labor cost records. Their handling is so standardized that we can transfer our cost men, if necessary, to any job, and they can readily pick up another timekeeper's or cost man's duties.

FORM VIII.

ABERTHAW CONSTRUCTION COMPANY

Job 1185 At Biddeford Me. 20th Week

LABOR STATEMENT COMPARISON

	W/E 7-13-20		W/E 7-20-20	
	Saving	Overrun	Saving	Overrun
Concrete	5214		5782	
Plant		883		1078
Forms		2877		4426
Reinforcement		79	118	
Excavation		4095		5666
Masonry	1228		1474	
Carpentry		1597		1606
Ironwork		199		243
Sash				
Painting				
Overhead, etc.				
Miscellaneous				
	6442	9730	7574	13019

Labor Overrun to 7-20 1920 - $ 5445.

Labor " to 7-13 1920 - $ 3288.

Weekly Payroll $ 8,758.49
" Teams 606.00
" Trucks 150.00
" Total $ 9514.49

Payrolls to date $ 97,691.30
Teams " " 7,995.00
Trucks " " 199.38
Total " " $ 105,885.68

FORM IX.

ABERTHAW CONSTRUCTION COMPANY.

Job No. 1175.

PAY ROLL.

AT TORRINGTON, CONN.

	Wed. 24.	Thurs. 25.	Fri. 26.	Sat. 27.	Sun. 28.	Mon. 29.	Tues. 30.	HOURS. R.	HOURS. O. T.	HOURS. S.
1	9		9	9	....	9	9	1 wk.	....	....
2	9		9	9	....	9	9	1 wk.	....	....
3										
4										
5	9		9	9	....	9	9	1 wk.	....	....
6	9		9	9	....	9	9	1 wk.	....	....
7										
8	9		9	9	....	9	9	1 wk.	....	....
9										
10										
11	9		9	9	....	9	9	1 wk.	....	....
12										
13										
14	9		9	9	....	6½	9	42½	....	....
15	9		9	9	....	9	9	45	....	....
16	9		9	9	....	9	9	45	....	....
17	9		9	9	....	9	9	45	....	....
18	9		9	9	....	9	9	45	....	....
19	9		9	9	....	9	9	45	....	....
20										
21	9		9	9	....	9	9	45	....	....
22	9		9	9	....	9	9	45	....	....
23	9		....	9	....	9	9	36	....	....
24	9		9	9	....	9	9	45	....	....
25										
26	9		9	9	....	7	9	43	....	....
27	9		9	9	....	9	9	45	....	....
28	9		9	9	....	9	9	45	....	....
29										
30										
31										
32	9		9	9	....	9	9	45	....	....
33	9		9	9	....	6	9	42	....	....
34	9		9	9	....	9	2	38	....	....
35	9		9	9	....	9	9	45	....	....
36	9		9	4	....	9	9	40	....	....
37	9		9	9	....	9	9	45	....	....
38	9		9	9	....	8	9	44	....	....
39	9		9	9	....	9	9	45	....	....
40										
41										
42										
43										
44										
45										
46										
47										
48										
49										
50										
	243		234	238	....	234½	236	1 185½	....	....

Holiday.

Sheet made out by H. W. Murdick.
Checked by H. S. Kinsley.

ABERTHAW CONSTRUCTION COMPANY.

PAY ROLL. — CONTINUED.

From 12-24-19 to 12-30-20.

	Rate.			Amount.	Date Pd. Off.	Man's No.		
	R.	O. T.	S.					
1	....	....	....	Pd. by B. O.	....	Supt.	2201	Richardson
2	$39.00	....	....	$39.00	....	Clerk	02	Kinsley
3							03	
4							04	
5	40.00	....	....	40.00	....	Steel Fore.	05	Hollen
6	48.00	....	....	48.00	....	Carp. Fore.	06	Howard
7							07	
8	21.00	....	....	21.00	....	Timekeep.	08	Murdick
9							09	
10							2210	
11	39.00	....	....	39.00	....	Lab. Fore.	11	Zavrello
12							12	
13							13	
14	.85	....	....	36.13	....	Carp.	14	
15	.85	....	....	38.25	....	Carp.	15	
16	.85	....	....	38.25	....	Carp.	16	
17	.85	....	....	38.25	....	Carp.	17	
18	.85	....	....	38.25	....	Carp.	18	
19	.85	....	....	38.25	....	Carp.	19	
20							2220	
21	.55	....	....	24.75	....	Steel	21	
22	.55	....	....	24.75	....	Steel	22	
23	.55	....	....	19.80	....	Steel	23	
24	.55	....	....	24.75	....	Steel	24	
25							25	
26	.70	....	....	30.10	....	Mech.	26	
27	.70	....	....	31.50	....	Mech.	27	
28	.70	....	....	31.50	....	Mech.	28	
29							29	
30							2230	
31							31	
32	.50	....	....	22.50	....	Labor	32	
33	.50	....	....	21.00	....	Labor	33	
34	.50	....	....	19.00	....	Labor	34	
35	.50	....	....	22.50	....	Labor	35	
36	.50	....	....	20.00	....	Labor	36	
37	.50	....	....	22.50	....	Labor	37	
38	.50	....	....	22.00	....	Labor	38	
39	.50	....	....	22.50	....	Labor	39	
40							2240	
41							41	
42							42	
43							43	
44							44	
45							45	
46							46	
47							47	
48							48	
49							49	
50							2250	

Approved, W. E. Richardson, Supt.

Approved, Inspect.

Page total, $773.53

Section II.

MATERIAL COSTS.

1. *Purchase Order.*

The first form necessary, of course, for material records is the Purchase Order. This form is made to give all the necessary information and to show what the material is to be used for which gives the cost man his distribution.

2. *Material Received Form.*

On receipt of the material, it is checked and entered on the Daily Material Received Form, showing the order number, vendor and material. On receipt of an invoice it is checked against this material received sheet for receipt of the goods.

3. *Invoice Record.*

When the invoice has been approved and passed for payment it is entered in the Invoice Record. There is a page here for each vendor, and all payments made are entered, showing the invoice number, commodity and amount. In the right-hand columns are shown the check number with which the invoice was paid, date and voucher number. The last column shows the statement number on which the invoices appear when the month's expenditures are reported to the owner.

A page is also used for the weekly pay rolls, and this register should check with the total of the Labor and Material Cost Books.

4. *Analysis of Estimate — Material.*

As stated previously, the Summary of the Estimate is divided into the Labor and Material Analyses. The Material Analysis shown here includes all the material to be used on the job, with the quantities, unit prices and total money; also the subcontracts, insurance and field office equipment.

This analysis is used for all material cost comparisons and by the Purchasing Department in checking up their purchases and prices submitted.

Form 53E. 9-24-19

ABERTHAW CONSTRUCTION COMPANY, AGENT
BOSTON, MASS.

VENDOR'S COPY

Job No. _____ } To be Marked on Invoice
Order No. E4753

PURCHASE ORDER

Date _____ 191 ___

TO _____

Ship to ABERTHAW CONSTRUCTION COMPANY, Agent

Address _____

Via _____

Invoice to _____ Owner
ABERTHAW CONSTRUCTION COMPANY, Agent

Mail Invoice to ABERTHAW CONSTRUCTION COMPANY, Agent

You agree to make shipment _____

From your STOCK—MILL—FACTORY _____

At _____

Address _____
SEND INVOICE IN TRIPLICATE and address all correspondence as above

Please furnish the following:

PRICE _____ USED FOR _____ Bldg. _____

F. O. B. _____ RECEIVED _____ Req'n No. _____ Auth'n No. _____

TERMS _____ BILL REC'D _____ Bill O.K.'d _____

We reserve the right to cancel in case of delay

Although the principal is solely responsible for the payment of materials and services furnished hereunder, the seller may with respect to materials and services so furnished deal with Aberthaw Construction Company as agent for said principal.

Owner's Name _____
By ABERTHAW CONSTRUCTION COMPANY
Agent

This confirms our mutual _____ agreement By _____

DETACH, SIGN AND RETURN ACCEPTANCE BELOW BY NEXT MAIL

ACCEPTANCE

Owner's Name _____ Date _____ 191 ___

ABERTHAW CONSTRUCTION CO., Agent

We accept your Order No. E4753 dated _____ on your Form _____

_____

CONSTRUCTION COSTS

179

FORM 170

ABERTHAW CONSTRUCTION COMPANY

MATERIAL RECEIVED

JOB NO. 1175

AT Torrington Conn DATE December 27 1919

ORDER NUMBER	DESCRIPTION	QUANTITY	FROM WHOM RECEIVED	DATE INVOICED	HOW DELIVERED	CHARGES	REMARKS IF CHARGEABLE TO MERCHANT NOTE IN THIS COLUMN
D 11944	Gravel	20 yds	Torrington Bldg. Co.	1/3	Truck		
E 6950	"	15 "	F.W. Fuller	1/6	"		
"	Sand	12 "	" "	1/6	"		
D 11977	12" Hacksaw Blades	12	W. H. Morrison		Messenger		
D 11978	Sledge Hammer Handles	6	Lyford Hdwe Co.		"		
"	8" Flat Files	6	" " "		"		
E 3619	Dragon Cement	231 lbs	Portland Stone Ware		Freight car 132208		

SIGNED ABERTHAW CONSTRUCTION CO.

PER H. S. Kinsley

180 BOSTON SOCIETY OF CIVIL ENGINEERS.

Form 242 3-24-23

PAGE 52

INVOICE RECORD

Job No. 1177 VENDOR Portland Stoneware Co

INVOICE NO.	DATE	MATERIAL	GROSS AMOUNT	DEDUCTIONS	DISCOUNT	NET AMOUNT	CREDITS	CHECK NO.	DATE OF CHECK	VOUCHER NO.	STATE. NO.
36	11-20-19	Cement	652 12		11 90	640 22		44	11-28-19	10	2
46	11-24-19	"	474 02		8 65	465 37		63	12-5-19	10	3
142	12-8-19	"	474 02		8 65	465 37		113	12-16-19	10	4
163	12-10-19	"	822 00		15 00	807 00		123	12-19-19	10	5
188	12-24-19	"	643 90		11 75	632 15		143	12-24-19	10	6
189	12-24-19	"	474 02		8 65	465 37		143	12-24-19	10	6
201	12-26-19	"	685 00		12 50	672 50		185	1-5-20	10	7
222	12-26-19	"	657 60		12 00	645 60		192	1-7-20	10	7
242	12-28-19	"	641 16		11 70	629 46		203	1-8-20	10	7
246	12-28-19	"	632 94		11 55	621 39		203	1-8-20	10	7
260	12-31-19	"	474 02		8 65	465 37		216	1-13-20	10	8
261	12-31-19	"	800 08		14 60	785 48		216	1-13-20	10	8
277	1-2-20	"	474 02		8 65	465 37		216	1-13-20	10	8
278	1-2-20	"	679 14	267 35	11 55	400 24		222	1-14-20	10	8
279	1-6-20	"	643 90		11 75	632 15		222	1-14-20	10	8
287	1-6-20	"	398 56		7 20	391 36		240	1-20-20	10	9
C.V. 1	2-26-20	" Job 1178					20 62 33			1	
C.V. 10	4-10-20	" bags					533 60	Check rcd to cover			21
C.V. 15	6-7-20	" "					31 13	"	" "	"	29

SECTION II. — FORM IV.

ABERTHAW CONSTRUCTION COMPANY.

Job No. 1175. January 8, 1920.

ANALYSIS OF ESTIMATE.

MATERIALS AND SUBCONTRACTS.

Cement	3 400 bbls.	$2.29	$7 790
Freight and loss on empties	3 400 bbls.	.05	170
Tests	3 400	.02½	85
Sand	3 850 c. y.	2.00	1 700
Gravel	1 500 c. y.	2.50	3 750
Peastone	50 tons	2.50	125
Cinders	220 c. y.	1.50	330
Plant: Small tools and supplies; Rental for mixer, motor, joists, towers; Power and fuel; Temporary buildings; Stagings, ladders and runs; Sawmill			2 300
Form lumber, 95M (less salvage)			5 000
Nails, oil and sundries			375
Metal forms erected	# 48	18.30	875
Lumber, 2-in. spruce planks	17M	65.00	1 105
3-in. planks	1⅓M	65.00	87
⅞-in. furring; 2 x 4 studding; ⅞-in. tongue and groove			50
1-in. maple flooring	10M	92.00	920
1-in. cork flooring	68 s. f.	.44	30
1-in. cell board	135 s. f.	.38	50
Building paper	76 rolls	3.50	266
Stair rail	80 ft.	1.00	80
Steel reinforcement	111 tons	80.00	8 880
Steel spirals	4 tons	100.00	400
Steel sash	6 800 s. f.	.353	2 400
Glass	6 100 s. f.	.13	800
Putty for glazing	3 200 lbs.	.06	192
Lime	4 tons	22.00	88
Terra-cotta blocks, 4 in.	5 400 s. f.	.12	648
Terra-cotta blocks, 6 in.	1 080 s. f.	.15	162
Nonpareil insulating brick, 4 in.	200 s. f.	.40	80
Nonpareil insulating brick, 2½ in.	160 s. f.	.30	48
Akron Tile Pipe, 8 in.	290 fl.	.30	87
Akron Tile Pipe, 6 in.	60 fl.	.20	12
Akron Tile Pipe, 5 in.	50 fl.	.20	10

SECTION II. — FORM IV. CONTINUED

Metal lath	8 s. y.	$1.30	$10
Sundry plaster materials			25
Freight elevator			3 475
Electrical contract			2 300
Heating and sprinkler contract			12 962
Plumbing			3 500
Cold weather materials			1 000
Liability insurance			1 500
Superintendent's salary, travel, board, stationery, office, etc.			1 600

5. *Material Cost Record.*

The Material Cost Record consists of a loose-leaf I. P. binder book. In it each item in the Material Estimate has a page, and the estimated quantity, amount and unit is entered at the top of the sheet. After the invoices for material have been checked and paid they are entered in the Material Cost Record. The date of the invoice, vendor's name, kind and amount of material, and cost, are entered.

There is also a column headed "Outstanding Orders," and the amount of an order, as soon as it is placed, is shown in this column in pencil. As payments on these orders are made they are entered in ink in the amount column, and the outstanding order figure reduced correspondingly. The next column is for credits and the last shows the total cost.

This book, then, contains all amounts paid for material on the job, and the total of this book and the labor cost record at the completion of the work must check with the total cost as shown in the bookkeeper's ledger. This book is the permanent record of the material costs, and is sent to the home office at the completion of the job.

6. *Material Cost Statement.*

In order to know how our purchases for material compare with the analysis of estimate, we make each month a Material Cost Statement similar to our Weekly Labor Cost Statement and show the overruns or savings on each item.

This form shows the item first, then the estimated and actual quantity, estimated and actual unit and estimated and actual cost. In the next column is entered the outstanding

SECTION II. — FORM V.

MATERIAL COST RECORD.

Job No. 1175.

Item, Form Lumber.

	Estimated.	Unit.	Estimated
	91M.	$55.00	5,000

Date.	Bought from	Amount and Description.	Cost.	Out-standing Orders.	Credits.	Cost to Date.
11-17-19	Torrington Building Co.	2 000′ 4 x 4 chestnut, 125/12′	.....	.....	.....	.....
		720′ 3 x 4 chestnut, 60/12′	.....	.....	.....	.....
		2 038′ 4 x 4 chest., 36/10, 81/12 and 14/14	$199.82	.....	.....	.....
11-18-19	J. C. Iffland Lumber Co.	4 010′ 2 x 6 N. C. pine	.....	.....	.....	.....
		2 502′ 1 x 8 N. C. roofers	.....	.....	.....	.....
		1 070′ 3 x 4 chestnut	.....	.....	.....	.....
		910′ 4 x 4 chestnut, oak and hemlock	424.82	.....	.....	$624.64
11-22-19	J. C. Iffland Lumber Co.	20 707′ 1 x 6 N. C. roofers	978.87	.....	.....	1 603.51
11-29-19	J. C. Iffland Lumber Co.	1 086′ 1¼ x 6 spruce, D4S	75.26	.....	.....	1 678.77
		756′ 2 x 4 x 18 rough spruce	.....	.....	.....	.....
		1 122′ 3 x 6 rough spruce	.....	.....	.....	.....
		476′ 4 x 6 rough spruce	.....	.....	.....	.....
		1 206′ 2 x 6 x 18 S2E spruce	.....	.....	.....	.....
		2 016′ 2 x 6 x 18 S2E spruce	386.42	.....	.....	2 065.19
12-1-19	J. C. Iffland Lumber Co.	13 603′ 3 x 4, 2 x 6, 3 x 6 rough and S2E spruce	942.69	.....	.....	3 007.88
12-2-19	J. C. Iffland Lumber Co.	4 779′ 3 x 4, 2 x 6, 3 x 6 D2E spruce	331.18	.....	.....	3 339.06
12-3-19	J. C. Iffland Lumber Co.	3 217′ 1 x 6 N. C. roofers	175.17	.....	.....	3 514.23
		7 074′ 6 x 6, 3 x 6, 1 x 6, 2 x 3, 2 x 6 and 1¼ x 4 rough spruce	490.23	.....	.....	4 004.46
12-4-19	J. C. Iffland Lumber Co.	3 130′ 3 x 6, 3 x 8, 1¼ x 4 rough spruce	216.91	.....	.....	4 221.37
12-5-19	J. C. Iffland Lumber Co.	5 375′ 1¼ x 4, 1¼ x 8, 1 x 6, 3 x 4 and 3 x 6 rough spruce	372.49	.....	.....	4 593.86
12-8-19		1 626′ 1¼ x 6 D4S spruce	.....	.....	.....	.....

12-8-19	J. C. Iffland Lumber Co.	1 216′ 3 x 4 and $1\frac{1}{2}$ x 4 spruce	$196.95	.....	.....	$4 790.81
12-9-19	J. C. Iffland Lumber Co.	2 193′ $1\frac{1}{4}$ x 6 D4S spruce	151.97	.....	.....	4 942.78
		340′ $1\frac{1}{4}$ x 8 D4S spruce	.....	.....	.....	.....
12-12-19	J. C. Iffland Lumber Co.	639′ $1\frac{1}{4}$ x 6 D4S spruce	67.84	.....	.....	5 010.62
		1 190′ $1\frac{1}{4}$ x 8 D4S spruce	.....	.....	.....	.....
		571 $1\frac{1}{4}$ x 6 D4S spruce	122.04	.....	.....	5 132.66
12-13-19	J. C. Iffland Lumber Co.	508′ 2 x 6 N. C. pine	29.67	.....	.....	5 162.33
12-15-19	J. C. Iffland Lumber Co.	115′ $1\frac{1}{4}$ x 4 D4S spruce	7.97	.....	.....	5 170.30
		366′ 2 x 3 D4S spruce	.....	.....	.....	.....
		476′ 3 x 4 x 14′ D2E spruce	.....	.....	.....	.....
		468′ 3 x 6 D2E spruce	90.78	.....	.....	5 261.08
12-24-19	J. C. Iffland Lumber Co.	2 010′ 1 x 6 rough boards	69.65	.....	.....	5 330.73
12-11-19	J. C. Iffland Lumber Co.	1 228′ $1\frac{1}{4}$ x 6 D4S spruce	85.10	.....	.....	5 415.83
3-31-20	Torrington Mfg. Co.	55 000 salvage, lumber at $35 per M	.....	.....	$1 925.00	3 490.83
3-30-20	A. C. Co.	P. C. salvage on lumber	.....	.....	17.00	3 473.83

SECTION II. — FORM VI.

ABERTHAW CONSTRUCTION COMPANY.

AT TORRINGTON, CONN.

Job No. 1175. MATERIAL STATEMENT TO FEBRUARY 2, 1920. Sheet No. 1.

ITEM.		QUANTITY. Estimate.	QUANTITY. Actual.	UNIT. Estimate.	UNIT. Actual.	COST. Estimate.	COST. Actual.	OUTSTANDING ORDERS.	SAVING.	OVERRUN.
CONCRETE.										
Cement	bbl.	3 400	3 378	2.29	2.29	7 740	7 740	.....		
Freight and loss on empties	bbl.	3 400	3 378	.05	.037	170	125	.....		
Tests	bbl.	3 400	3 378	.025	.025	85	85	.....		218
Sand	c. y.	850	829	2.00	2.05	1 658	1 236	470		
Gravel	c. y.	1 500	1 405	2.50	2.66	3 513	3 404	332		
Peastone	t.	50	45.5	2.50	2.33	114	42	64		
						13 280	12 632	866		
Plant	$	2 300	.....	.....	.....	2 100	4 249	100		249
Estimated credit	$	.....	.....	.....	.....	2 000	.....	.....		
FORMS.										
Form lumber	M	91	91	55.00	59.50	5 000	5 416	.....		
Nails, oil and sundries	$	375	.....	.....	.....	375	933	45		218
Metal forms erected, No. 48	$	875	.....	.....	.....	875	573	301		
Estimated salvage on form lumber	$	.....	.....	.....	.....	800	.....	.....		
						7 050	6 922	346		
LUMBER.										
2″ spruce plank	M	17	20.5	65.00	55.75	1 105	.....	1 142		
3″ plank	M	1	1.5	65.00	70.00	87	.....	109		
$\frac{7}{8}$″ furring 2 x 4 studding, $\frac{7}{8}$″ tongue and groove	$	50	.....	.....	.....	50	.....	89	170	
1″ maple flooring	M	10	10	92.00	93.00	920	.....	930		
1″ cork flooring	s. f.	68	68	.44	.155	30	11	.....		
1″ cell board, 135 s. f.	$	50	.....	.....	.....	50	32	.....		
Building paper	roll	76	7	3.50	3.50	266	.....	25		
						2 508	43	2 295		

REINFORCEMENT, ETC.										
Steel bars	t.	111	125.7	80.00	77.40	8 880	9 721	.....	1 247	
Steel spirals	t.	4	2	100.00	100.00	400	199	.....		
Steel sundries		.....	.....	.....	.....	.....	45	.....		
Estimated credit on steel		.....	.....	.....	.....	1 800	.....	.....		
Steel sash	s. f.	6 800	6 800	.353	.332	2 400	2 276	.....		
Putty for glazing	lbs.	3 200	3 400	.06	.058	192	187	10		
Glass	s. f.	6 100	6 100	.131	.129	800	787	.....		
						14 472	13 215	10		
MASONRY.										
Lime	t.	4	1.75	22.00	53.00	39	92	.....	149	
Terra cotta blocks, 4″	s. f.	5 400	6 600	.12	.117	648	420	123		
Terra cotta blocks, 6″	s. f.	1 080	200	.15	.....	162	.....	32		
Nonpareil insulating brick, 4″ and 2½″	$	128	.....	.....	.....	128	160	.....		
Akron tile pipe, 8″, 6″, 5″	$	109	.....	.....	.....	109	131	.....		
Metal lathe	$	10	.....	.....	.....	10	6	.....		
Sundry plaster material	$	25	.....	.....	.....	20	.....	3		
						1 116	809	158		
Saving $881						42 526	37 870	3 775	1 566	685

orders. In the estimated quantity column is entered the total quantity as shown in the Analysis of Estimate and in the actual quantity column the quantity actually paid for. This statement is made to show as nearly as possible not only what the overrun is at the time the statement is made, but the final overrun or saving.

Of course, on the first three or four statements on a job that will take ten months to complete this is not possible, as all purchases will not be made or all contracts let, but in a very short time this comparison will indicate quite clearly the saving or overrun on the material costs that will show at the completion of the work. In addition to the outstanding orders being shown, we also estimate salvages and credits on plant, form lumber, etc., and include these figures in our statement.

Three copies of this monthly Material Statement are made. Two copies are sent the home office, — one for the general superintendent and one for the Cost Department. The third copy is for the job files.

We have, therefore, in the home office each week a Labor Cost Statement and each month a Material Cost Statement.

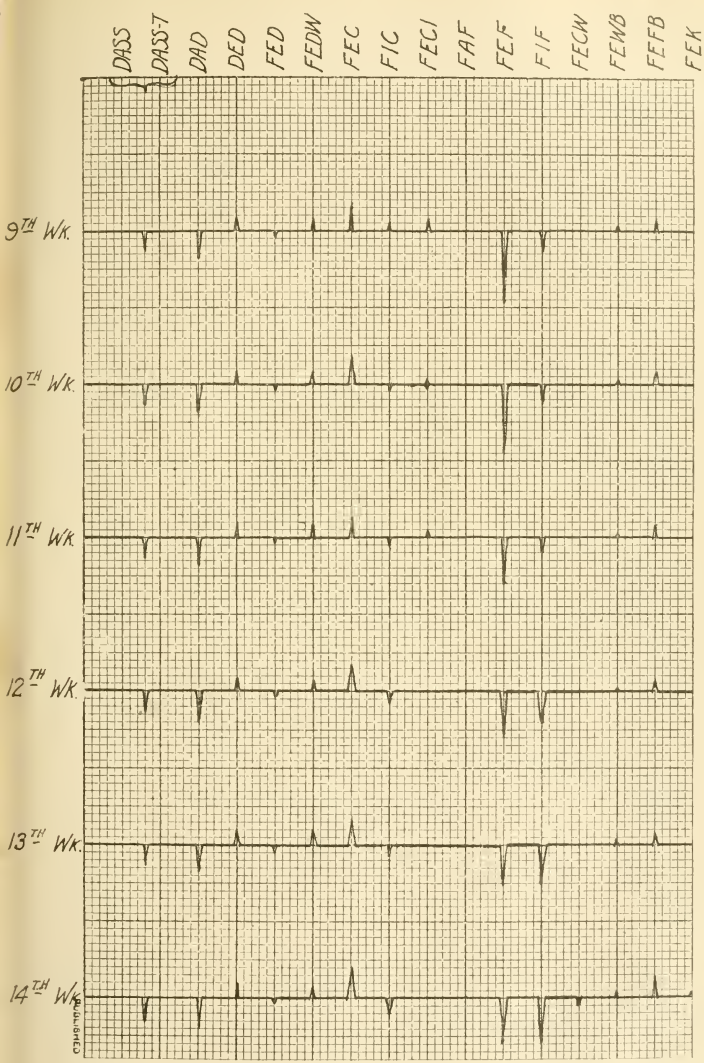
7. *Tabulating Job Cost by the Graphic Method.*

The purpose of this graphic chart is to place before the general superintendent and construction manager the status of the job and enable them to quickly pick out those items which are above the estimate and need special attention.

This chart shows what the final overrun or saving will be on the various items if the unit obtained to date is maintained for the remainder of the work.

A valuable feature of this chart is that the quantity of work influences the tabulation, thereby showing that a small overrun on a very large quantity would result in a much larger money overrun at the end of the job than a large overrun on a small quantity of work. This would indicate that the large quantities of work to be performed should have the first attention in getting low unit costs.

On our Labor Cost Statement you will remember we show the saving or overrun to date on the various items of work.



SECTION II. — FORM VII.

Job No. 1145. ABERTHAW CONSTRUCTION COMPANY.

COST SUMMARY.

MANUFACTURING BUILDING FOR E. A. MALLORY & SONS, INC., DANBURY, CONN.

Date started, 4-17-19. Date completed, 10-24-19.

	Item.		Quantity.	Labor. Mix. Place.	Unl. Cem.	Unl. Agg.	Total Unit.
	CONCRETE.						
1	Footings, columns, floors, roof, etc.	c. y.	2 077	1.20	.338	.935	2.47
2	Window sills, coping, etc.	f. l.	1 548	.15	.0029	.021	.173
3	Carbo. rub, inside and outside	s. f.	14 210	.143	....	....	.143
4	Granolithic finish, laid after	s. f.	28 000	6.20	.29	.38	6.87
5	Unload and handle cinders	$	.....	....	....	....	18.00

			Quantity.	Mix, Tend, Lay.	Unl. Cem.	Unl. Sand.	Total Unit.
	MASONRY.						
6	Unload, mix mortar, tend and lay 4" x 6" T. C., part incl. stagings	s. f.	5 861	13.30	.12	.187	13.61
7	Plaster partitions and metal sash	s. y.	1 291	.582	.018	.0077	.607
8	Picking second-floor ceiling for plaster	s. y.	970	.098	....	....	.098
9	Plaster second-floor ceiling	s. y.	970	.457	....	....	.457
10	Metal lath partitions	$	.....	.....	....	....	64.00

			Quantity.	Make Erect Strip.	Unl. Lumb.		Total Unit.
	FORMS.						
11	Footings, foundations, brook wall, etc.	s. f.	16 808	7.98	.17	....	8.15
12	Floors, beams, curtain walls, etc.	s. f.	46 422	11.30	.17	....	11.47
13	Columns and mullions	s. f.	7 852	17.90	.17	....	18.07
14	Sidewalk	$	.....	.....	....	....	47.00
15	Windows, coping, etc.	f. l.	1 590	.27	.0009	....	.2709
16	Brook wall under first floor	$	.....	.....	....	....	144.00
17	Tunnel walls	$	.....	.....	....	....	383.00

			Quantity.	Bend and Place.	Unl. and Team.		Total Unit.
	REINFORCEMENT.						
18	Cut, bend and place, including spirals	t.	84.74	14.99	2.29	....	1 728

			Quantity.				
	EXCAVATION.						
19	Clear site	$	.....	.....	....	....	307.00
20	Dig footings, foundations, etc.	s. y.	1 742	1.06	....	....	1.06
21	Backfill	$	.....	.....	....	....	438.00
22	Sheeting	$	.....	.....	....	....	353.00
23	Coffer dam	$	.....	.....	....	....	652.00

			Quantity.	Labor Unit.			Total Unit.
	CARPENTRY.						
24	Framing, temp. roof, etc.	M	31	16.95	....	....	16.95
25	Erect wood partitions, sash, doors, etc.	s. f.	3 330	.75.	....	....	.75
26	Setting wood doors	$	.....	.....	....	....	742.00
27	Setting wood sash	s. f.	3 784	.241	....	....	.241
28	Carpentry work — bulkhead	$	....	.....	....	....	65.00

ABERTHAW CONSTRUCTION COMPANY.

COST SUMMARY. — CONTINUED.

MANUFACTURING BUILDING FOR E. A. MALLORY & SONS, INC., DANBURY, CONN.

Supt. John L. Noel

	MATERIAL.				PLANT.				Total Unit.	Total Cost.
	Cost. Cem.	Cost. Agg.		Total Unit.	Labor.	Sup-lies.	Frt. Rental.	Total Unit.		
1	3.40	1.825	....	5.225	.627	.795	1.04	2.46	10.15	20 831
2	.029	.0401	....	.0692	.0154	.019	.0254	.059	.30	469
3	.....	.....	.....	.....	....	....	....	....	.143	2 044
4	2.97	.86	....	3.83	....	....	....	....	10.70	2 997
5	.....	.....	....	.....	....	....	....	....	.....	18
										26 359
	Cost. Cem.	Cost, Brick and Tile.	Misc. Mat.	Total Unit.					Total Unit.	Total Cost.
6	1.34	17.00	1.62	19.96	....	....	....	....	33.57	2 000
7	.182	.....	.021	.203	....	....	....	....	.81	1 048
8	.....	.....	....	.....	Air ha	mmers	& poin	ts .085	.183	178
9	.....	.....	.109	.109	....	....	....	....	.566	562
10	.....	.....	....	56	....	....	....	....	.....	120
										3 908
	Cost, Lumb.	Misc. Mat.		Total Unit.					Total Unit.	Total Cost.
11	6.64	1.10	....	7.74	....	....	....	....	15.89	2 664
12	6.64	1.10	....	7.74	....	....	....	....	19.21	8 944
13	6.64	1.10	....	7.74	....	....	....	....	25.81	2 028
14	.....	.....	....	.....	....	....	....	....	....	47
15	.0299	.0055	....	.0354	....	....	....	....	.306	494
16	.....	.....	....	.....	....	....	....	....	.....	144
17	.....	.....	....	.....	....	....	....	....	.....	383
										14 704
	Cost. Steel incl. Spira's.	Misc. Mat.		Total Unit.					Total Unit.	Total Cost.
18	75.80	.518	....	76.318	....	....	....	....	03.598	7 964
									Total Unit.	Total Cost.
19	.....	.....	....	.....	....	....	....	....	.....	307
20	.....	.....	....	.....	....	....	....	....	1.06	1 851
21	.....	.....	....	.....	....	....	....	....	....	438
22	.....	.....	....	276	....	....	....	....	.....	629
23	.....	.....	....	.....	....	....	....	....	.....	652
										3 871
				Total Unit.					Total Unit.	Total Cost.
24	.....	.....	....	.....	....	....	....	....	16.95	524
25	.....	.....	....	2.27	....	....	....	....	3.02	10 037
26	.....	.....	....	.....	....	....	....	....	.....	742
27	.....	.....	....	.018	....	....	....	....	.259	982
28	.....	.....	....	.....	....	....	....	....	.....	65
										12 350

Any seemingly small unit overrun on this labor statement would not always cause serious comment on the part of the job superintendent or management, but on these charts this small unit overrun, if it applied to a large quantity of work, would result in a very large money loss at the end of the job.

Plotting these costs each week, directly under the previous weeks, shows any variations and can be easily studied, compared and acted upon immediately before it is ancient history and too late to do any good.

8. *Final Cost Summary.*

At the completion of the job and after all bills have been paid, the final cost summary is worked up. The labor, material and plant units are shown separately and each divided into two or more items, and the total unit and total cost obtained.

These summaries are blue-printed and a copy furnished the Estimating Department.

Attached to this summary is a Job History, giving information regarding —

Personnel;
Prices paid for cement, sand, brick, etc.;
Nature of the soil;
List of subcontractors;
Wages paid labor;
How concrete was distributed, whether by buggy or chutes;
Number of towers and height, etc.

9. *Cost Comparisons.*

In order to stimulate interest among our foremen we have been making up at the home office weekly comparative cost statements showing the units obtained on various jobs for similar classes of work. On this comparison we show the bogey unit allowed each job on the items compared, the quantity done, and the unit obtained on the job. Under each job we show the superintendent and foremen's names, and the units below the estimate have a square around them, and the foreman showing the best performance as compared with his own estimated unit has a star opposite his name. We find that these comparisons arouse considerable interest and some rivalry.

COMPARISON OF UNIT COSTS TO DATE FOR JOBS WITH SIMILAR ITEMS OF WORK

DATE 1/6/20

	JOB NO. 1185	JOB NO. 1188	JOB NO. 1191	JOB NO. 52	JOB NO. 54
	LOCATION Biddeford, Me.	LOCATION Somersworth, N.H.	LOCATION Worcester, Mass.	LOCATION Danville, Va.	LOCATION Durham, N.C.
	SUPT. H.S. Wright	SUPT. H.V. Shea'han	SUPT. J.J. Keane	SUPT. J.D. Henderson	SUPT. Clasby & Marshall
	FOREMAN (D&M) D. Grosse*	FOREMAN J. Sully Buchinni	FOREMAN T. Grosse *	FOREMAN (D) Bussey	FOREMAN White
	FOREMAN (F) McCarron	FOREMAN Reeks	FOREMAN Cairns *	FOREMAN (F) McCarthy	FOREMAN Robinson
	FOREMAN (R) Lynch	FOREMAN Davis *	FOREMAN Nichols	FOREMAN (R) Greenwood	FOREMAN Newsome
				FOREMAN (M) Masselli *	FOREMAN Murphy

SYMBOL	QUANTITY	UNIT	EST.	ACT.	QUANTITY	UNIT	EST.	ACT.	QUANTITY	UNIT	EST.	ACT.	QUANTITY	UNIT	EST.	ACT	QUANTITY	UNIT	EST.	ACT.
Dad	2186	cy	5.82	5.49	3361.6	cy	5.90	8.55	270	cy	3.25	*2.10	1338	cy	4.20	3.88	2019	cy	1.92	1.99
Fef	1380	Sqs.	6.08	7.50	3532.2	Sqs	7.10	10.40	485	Sqs	7.10	*6.20	5286	Sqs	7.50	11.61	1213	Sqs	7.05	12.00
Ref	323.88	T	8.63	7.88	834.86	T	10.60	*6.76	85	T	8.00	10.49	1374	T	9.30	11.32	229	T	8.26	7.35
Med	632	cy	2.60	*1.27	1090.1	cy	2.90	2.41	230	cy	2.40	1.53	1070	cy	2.78	2.54	703	cy	1.87	2.80
Mef	6323	cy	2.08	*1.65	16610.9	cy	2.15	2.19	1843	cy	2.25	2.54	27985	cy	2.40	2.72	5655	cy	2.30	3.14
Mecw													844	cy	5.04	*6.42	60	cy	5.40	10.02

Shows units below bogey

* Shows best performance

CONSTRUCTION COSTS.

The quantity man, of course, has to keep in very close touch with the timekeeping and cost departments. He reports the quantities under the symbols as shown on the Analysis of Estimate, and must keep these right up to date in order to insure the cost statement being completed promptly.

On small jobs the reporting of quantities will be done by the engineer, but on large operations one man will be assigned to this work alone. Without good accurate quantities up to date at all times the cost data are, of course, practically useless.

Does it pay?

You may say, "Well, this seems to be a good system, but does it pay?" I think it does.

On one job, recently, the brick costs were high compared with the estimated unit. It was found that masons were laying 1 100 to 1 200 brick a day, a good average for that particular class of work, so attention was given to the tending It resulted in a rearrangement of the delivery of the brick to the elevator, and a very substantial saving on the unit per thousand. The costs showed this high unit at once, and afforded the means of rectifying it before it was too late.

On a large job in the South, last summer, the labor overrun was steadily increasing, and a detailed study of the costs was made. It was found that 60 per cent. of the overrun was in the form work, and further, that 80 per cent. of this 60 per cent. was in two items. You can readily see that this gave to the management a big advantage in showing them what to concentrate on. This they did, with the result that many thousands of dollars were saved and the curve showing the overrun flattened out, and remained practically so during the remainder of the work.

On one job the cost of laying maple flooring was running high. A man was set to watch the operation. The building had square interior as well as exterior columns, the corners of which had been chamfered by fitting a fillet in the column form. When the edge strip was fitted around these columns a small triangular piece was fitted into the chamfered space. Time

taken on this one operation showed that it added 20 cents per square over the whole floor, as there were four pieces fitted to each interior and two to each exterior column, or twelve to each bay. It was too late to make the maximum saving of 20 cents per square on this job, but by filling these holes with neat cement mortar the cost per square was reduced about 13 cents, and on the next similar building, by cutting off the fillet strip on a bevel just above the level of the edge strip, the full 20 cents per square was saved.

On another job the cost of laying floor plank was high. A time study was made and several reasons discovered for the high cost, one being the high cost of lumping, largely due to lack of proper planning. The cost prior to the time study was $10 per thousand board feet. The time study showed that it could be done for $5.25 if done at 100 per cent. efficiency. The final average for this job was $8.65.

The above are some examples where the savings can actually be traced to our cost system. We feel that there are many other instances where savings are made and economies obtained and that if all contractors could establish some such system it would be of great advantage to all

DISCUSSION.

LEONARD C. WASON.* — I think that Mr. Connor has proved most conclusively that it does pay. The company developed a cost accounting system at a very early date. The present system is the outgrowth of experience. Its first object is to give promptly information to the job superintendent wherein work is costing too much, so that it can be quickly corrected. Its secondary object is to obtain accurate data for assisting in making future estimates of the cost of similar work.

I will cite one of our early contracts, twenty or more years ago, when dollars counted a great deal in the results accomplished.

* President, Aberthaw Construction Company, 27 School Street, Boston, Mass.

Before building the concrete fence around Harvard's Athletic Field, we made an estimate of cost of labor per lineal foot of posts above the horizontal beam at the ground level, of $1.00 per lineal foot. The first week these were started the cost was $2.40 per lineal foot. I had the report on Saturday morning, and when I went to pay off I called the attention of the foreman to this item. He said he was doing the best he could. I couldn't stop to look into it then, but on Monday morning I went over, spent the forenoon there, and gave him my ideas as to how he could straighten it out. The result was that the cost dropped to between fifty and sixty cents per lineal foot, and did not exceed the estimate again during the life of the job, which ran several months. Prompt action changed a loss into a profit without any loss in quality of work. The great thing is to check the work when you can act on what you find instead of when it has become ancient history.

I know one large local construction firm which has a most elaborate cost system, but they do not obtain their records until about three weeks after the work has progressed. It is then ancient history, — too late to act in order to correct expensive items.

Eight to twelve items, out of the fifty to seventy total into which our records are subdivided, include nearly 80 per cent. of the total cost of all operations. These are analyzed and on the superintendent's desk at ten o'clock on the morning following the execution, and he has all the rest of the day to act upon them, if necessary. So our costs enable him to keep the work under absolute control, and, thereby, savings are made.

I assure you most positively that it does pay. It paid several years ago when we were doing strictly lump-sum contract work, and it pays much more now on percentage work. It keeps the work under absolutely close control. It also keeps us on very friendly terms with the owner. I wish that more contractors did it. If they did there would be fewer failures and there would be more profits made in the contracting business.

To illustrate by one comparison before closing, as to the difference in cost between lump-sum bidding and percentage work. We have had two cases — one a very small contract and

one fairly sizable — where the owners received lump-sum bids and thought them rather high. They were strictly competitive bids from several contractors. They were rejected and we were awarded the contract on a cost-plus basis. We completed the small job about 4 per cent. under the lowest bid, and on the large job we saved over 10 per cent., showing that work on a percentage basis and with the cost under close control can be done cheaper than on the lump-sum contract basis.

MEMOIR OF DECEASED MEMBER.

LOUIS BERTRAND VAUGHAN.*

Louis Bertrand Vaughan, the son of Andrew Jackson Vaughan and Esther Norris Vaughan, was born in Boston, Mass., August 22, 1858, and died at Providence, R. I., July 22, 1920. He came of New England ancestry and was a lineal descendant of George Vaughan, who had the commission of colonel in the provincial forces during Queen Anne's War and in 1715 was appointed lieutenant-governor of the province of New Hampshire.

Louis Bertrand Vaughan received his early education in a private school in Providence, R. I., and in 1878 was graduated from the English High School to take up engineering work in the city engineer's office in Providence.

From 1878 to May, 1886, he was engaged as rodman, instrumentman and assistant engineer in city property, sewer and highway departments, on surveys and on the construction of sewers and roads, for the city of Providence. For a short while after this, Mr. Vaughan engaged in private practice as a civil engineer in Providence, but left that in May, 1887, to take up cable railroad work. While engaged in this special field, he acted as assistant engineer for the Cable Tramway Company, of Omaha, Neb., first in immediate charge of construction of power house and installation of driving-plant, and second season in charge of surveys for and construction of cable roadway. From February, 1889, to April, 1890, Mr. Vaughan was assistant engineer with the Denver (Colorado) City Cable Railway Company, in charge of surveys for and construction of roadway of Larimer Street Line, and Larimer Street and 16th Street

* Memoir obtained by Frank E. Winsor and substantially as prepared for the American Society of Civil Engineers.

viaducts. The remainder of the year 1890 was spent in Cleveland, Ohio, with the City Cable Railway Company, in charge of construction of one division of road, including track and vault work.

In February, 1891, Mr. Vaughan was appointed assistant engineer of the Brooklyn (N. Y.) Heights Railway Company, in charge of the construction of the power house and installation of the plant, Montague Street Cable Road. From July, 1891, to April, 1893, he was assistant engineer on Broadway and Seventh Avenue Railway Company, New York City, in charge of construction of a section of the cable railway from Waverly Place to 17th Street, and later of the Houston Street Power Station, including the installation of driving machinery.

For a short time after this, Mr. Vaughan returned to private practice as a civil engineer in Providence. In April, 1895, he went to Cambridge, Mass., as assistant engineer in charge of the construction of several sections of the 2 500 000 000 gal. Hobbs' Brook Storage Basin of the water works, the last six months as resident engineer in entire charge of the completion of the work and of final estimates. This work was followed by a short period as assistant engineer in charge of the surveys for a section of a high-level sewer of the Massachusetts Metropolitan Sewerage Commission.

From December, 1898, to May, 1902, Mr. Vaughan was with the Boston Elevated Railway Company as assistant engineer on calculations for the steel structure, in charge of the construction of pile and concrete foundations on a section of the road, on design of special track work, and in charge of re-arrangement of tracks, installation of third rail and changes in station platforms of the Boston subway. During the last six months he was in the roadmaster's office, in charge of track repairs on the elevated structure and in the subway.

From May to September, 1902, he was with Westinghouse, Church, Kerr & Co., in charge of the surveys on a section of high-speed electric railroad in central New York state, but here his health broke down and he was obliged to resign.

For about three years after this, Mr. Vaughan was with Percy M. Blake, civil and hydraulic engineer, Newtonville,

Mass., as assistant engineer in charge of surveys, designs and estimates for water works and water-power development and valuation of water-works properties in various places in Massachusetts and Connecticut.

It was not until February, 1906, that he was connected with the Board of Water Supply, Reservoir Department, for New York City. At that time he was appointed assistant engineer in charge of the real-estate surveys. From 1909 to 1911 Mr. Vaughan was a section engineer in charge of the construction of the intercepting sewer in Kingston, N. Y. During 1912–13 he occupied a similar position on bridge construction for the highway around the reservoir, including the Travers Hollow bridge. In 1914 Mr. Vaughan was on the fencing and highway surfacing contracts around the reservoir.

In April, 1915, he was transferred to the Southern Aqueduct division at Valhalla, N. Y., where he was engaged on the final estimates for the Kensico Reservoir, including bridges and highways. On March 3, 1916, Mr. Vaughan retired from the engineering profession, to spend the remainder of his life in Kingston, N. Y.

On September 21, 1882, Mr Vaughan was married to Miss Ida Etta Hall, of Providence, R. I. In the fall of 1918, after a year's sickness, Mrs. Vaughan died at Kingston, N. Y. From this blow Mr. Vaughan never recovered. Worn down by the grief and sorrow of her sickness and death, pernicious anemia did its deadly work, and in less than two years Louis Bertrand Vaughan died, at the home of his brother, in Providence, R. I. Here he was laid to rest beside his wife, in the North Burial Ground.

He is survived by a brother, Frank Leslie Vaughan, secretary and treasurer of the Providence Engineering Corporation, Providence, R. I., and an only son, Victor Hall Vaughan, a graduate of Harvard College, class of 1918.

From 1906, when Mr. Vaughan joined St. John's Episcopal Church in Kingston, N. Y., he held the various offices of vestryman, senior warden and church treasurer. At the time of his death he was senior deacon of Kingston Lodge, No. 10, F. & A. M.; a past high priest of Mount Horeb Chapter, R. A.,

Kingston; commander of Rondout Commandery, No. 52, Knights Templar, Kingston, N. Y., and a member of Cyprus Temple, Mystic Shrine, of Albany, N. Y. He was also a member of the American Society of Civil Engineers, New York City, and of the Boston Society of Civil Engineers.

Mr. Vaughan was a man of quiet nature and fond of home life. In his profession he was a diligent and conscientious worker, never allowing his own personal feelings and comfort to interfere with the carrying our of his duties and obligations. He was a wide reader, especially in the field of literature and history, and throughout his life was much of a scholar. To those who really knew him, his extraordinary kindness and devotion to high ideals gained him a name to be envied.

"A good name is rather to be chosen than great riches, and loving favour rather than silver and gold."

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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THE PUBLIC WORKS OF MODERN GREECE.

By Walter E. Spear,* Member Boston Society of Civil Engineers.

* Board of Water Supply, City of New York, N. Y.

(Presented April 20, 1921.)

With a staff of American and Greek engineers, the writer, as the representative of Ford, Bacon and Davis, Engineers of New York City, made, last year, an investigation in Greece for a complete system of water supply and sewerage for the cities of Athens and Piræus. Compared with the eastern part of the United States, Greece is a very dry land. The entire annual rainfall is small; that during the summer almost negligible, and all available water not required for the needs of men and animals is used for irrigation. The problem of developing an adequate supply of water for a population of 370,000 people, now living in the above communities, without prejudice to other interests, was not, therefore, a simple one, and all possible sources of supply within 100 miles of Athens were considered. These investigations took the writer over a large part of Southern Greece and gave him an opportunity to see something of the existing public works and to learn from some acquaintance with public men the needs of modern Greece.

Need for Modern Public Works.

Modern Greece has a few handsome public buildings, as seen in Fig. 1, some well-paved city streets, an insufficient mileage of indifferent highways, a few trolley roads and an inadequate

railroad system, but really possesses no modern public works comparable with those of the progressive countries of modern Europe. Ancient Greece has left ruins of the most magnificent public buildings and monuments ever fashioned by man, some water works still in serviceable condition, a few drains and some traces of old highways. The Greeks, in their small city states, were not great road builders, and the Romans in their time did little in Greece, so that in the most essential requirement of a



FIG. 1. ACADEMY OF SCIENCE, ATHENS.

commercial state, adequate transportation, ancient Greece was ill-provided. As now, the great need in ancient times was money with which to carry on large public works. In classic Greece, huge sums were spent in beautifying the cities, and more productive public works were neglected. During the last eight years, modern Greece has spent large sums of money on its army when it could have better been spent on water, sewerage and drainage works, more and better highways, additional railways and improvements of existing lines, and extensive port developments.

Water Works.

With an annual rainfall over large areas of Southern Greece of less than twenty inches, most of which falls in the months of October to May, inclusive, and with a high percentage of run-off from rocky, mountain slopes and semi-impervious soils, the amount of water available during the long, almost rainless summers is consequently small. Surface reservoirs for the storage of the winter rains have seldom been constructed, and the conditions are not generally favorable for such construction. The



FIG. 2. FOUNTAIN IN VILLAGE OF SOUVALA, NEAR MT. PARNASSUS.

underground storage in the seams and channels of the limestones and shales of the mountains and in the occasional beds of porous gravels and conglomerates of the large valleys is insufficient to maintain the flow of the springs, which, with wells, provide water throughout the year for all purposes, and the yield of these springs falls off very materially toward the end of the summer.

Outside of the larger cities, water is seldom piped to private dwellings; every householder carries his supply from the constantly flowing fountains, shown in Figs. 2 and 3, which are so

conspicuous a feature of the Greek villages. Often the container is a 5-gallon can provided by the Standard Oil Company. The water from these fountains appears to be of a satisfactory quality, except for the universal hardness. It is generally cool, though an agreeable temperature cannot be long maintained without ice during the heat of the summer, even when placed in porous jars. The amount of water actually used in these villages is naturally small, but none is lost, since the overflows of the fountains irrigate the village gardens and perhaps the fields outside. When the larger villages in Greece, which are now favored with suffi-



Fig. 3. Fountain at Thebes.

cient water for their public fountains, install modern plumbing and begin to use as much water as other Mediterranean communities in France, Italy, or even in Egypt, it is going to be difficult to find sufficient water for their needs. Some villages, to which most of the water used is hauled several miles in barrels, may never be able to procure enough water to greatly raise their present standard of cleanliness. In some localities surface water might be developed, but the prejudice against its use for domestic consumption is very strong and cannot be readily overcome.

The largest problem in water supply in Greece, and one that has been considered for some years by the Greek government,

is that of providing an adequate supply of water for the cities of Athens and Piræus. These cities sometimes have during a dry summer but little more than ten gallons per capita, quite insufficient for their needs. Most of the Athens supply is furnished by the aqueduct and galleries, some 16 miles in length, that were built in the second century of this era, during the reign of the Emperors Hadrian and Antoninus Pius. The covered reservoirs at the end of the Hadrian aqueduct are seen in Figs. 4 and 5. The Hadrian aqueduct was built as a tunnel through the lime-



Fig. 4. Storage Reservoir in Athens, at end of Hadrian Aqueduct.

stones and conglomerates of the hillsides and valleys back of the city and is in some places 120 feet below the surface. The supply from this aqueduct is extremely hard but otherwise satisfactory. Some additional water for Athens is provided by large open wells in the vicinity, and all of the inadequate supply delivered to Piræus comes from similar sources near that city, which provide a water much inferior in quality to the supply of Athens.

Most of the new sources of supply proposed for Athens during the past thirty years or more have been distant springs, the immediate development of which would represent a heavy burden upon the financial resources of the cities to be served.

English, French and Austrian engineers have from time to time reported on the project of bringing to Athens and Piræus a supply of 20 million gallons or more of water from the springs near Lake Stymphalia, in the Peloponnesus, some 70 miles away in a straight line. The springs are at an elevation of about 2 000 ft. and may be brought to Athens by gravity, but at the Isthmus of Corinth the necessary siphon at approximately sea level would be subjected to a very heavy pressure to deliver the water in Athens at the level required. Other sources that have been



Fig. 5. Storage Reservoir in Athens, at end of Hadrian Aqueduct.

suggested are large springs in Bœotia, at the headwaters of the Melas River in the basin of Lake Copais. These springs have an elevation of only 300 to 400 ft. above sea level and, though somewhat nearer Athens than those at Lake Stymphalia, would require pumping against a high head to get them over the Cithæron or Parnes mountains, lying between Bœotia and the plains of Attica, in which Athens is located. The writer reported on still another source of supply somewhat farther away than either of the above, on the slopes of Mt. Parnassus, at an elevation of about 1 000 ft. The valley in which these springs occur is seen in Fig. 6. These sources, which would supply fully as much water as those at Lake Stymphalia, may be brought to

Athens in a gravity aqueduct that could be located over much more favorable ground than that from Lake Stymphalia, and a first development of surface water could be made along this aqueduct not far from Athens, at a favorable site for a large storage reservoir, which would serve to equalize the flow of the springs of the Parnassus sources. This development of surface water would represent a first step in the construction of the entire project.



FIG. 6. VALLEY NEAR MT. PARNASSUS.

Sewerage.

Modern sewerage works can hardly be said to exist in Greece outside of Athens and in some of the other large cities, and there is little likelihood of any immediate construction of sewerage works except in Athens and Piræus. The general demand for modern sanitation does not appear to be sufficiently great to keep the cities and villages clean with their present facilities or to overcome in many localities the difficulty of finding sufficient water for modern sewerage works, or of securing enough money to build them.

Some traces of the sewers of ancient Athens have been found, but these sewers, dating back to the fifth century B. C., were

probably built for storm-water drains and were not intended for the carriage of house sewage. Portions of modern Athens have storm-water drains which carry house sewage, though they were not intended for that use and are ill-designed for the purpose, having large and irregular sections and flat inverts. They are all built of rough rubble, plastered on the inside. A view of the outfall sewer of Athens, which carries the sewage to the channel of the Cephisus and to the irrigating ditches below it, is seen in



FIG. 7. OUTFALL SEWER NEAR DANIEL'S CHURCH, ATHENS.

Fig. 7. Large areas in Athens are served by cesspools, and more primitive methods of disposal in open privies or pits are common in the poorer quarters. The need of Athens for a modern system of sewers is great, and proposals have been repeatedly made to provide such works. A few years ago, a German engineer prepared plans for a combined system of sewers for Athens and Piræus. The writer, however, after consideration of the problem, adopted a separate system and prepared plans and estimates on that basis. This solution of the problem promised a more satisfactory method of disposing of the house sewage in a city surrounded by steep, rocky hillsides, from which the heavy winter rains would wash into a combined system of sewers so much

detritus as to obstruct the summer flow of house sewage and create a nuisance.

The adoption of the separate system would permit the use of the existing sewers as a part of the storm-water drainage system, and would allow of safely discharging all storm water in Athens through comparatively short connections into the adjacent channels of the Ilissus and the Cephisus, and that in Piræus directly into the harbor. The difficulties of tearing up the narrow, tortuous streets of Athens and Piræus, such as are



FIG. 8. NARROW STREET IN OLDER QUARTER OF ATHENS.

seen in Fig. 8, and of laying sewers and storm-water drains as well as water mains there, may only be appreciated by those who have faced some such task elsewhere, and know besides something of local conditions in these Greek cities. The work would necessarily involve careful planning and thorough organization, not to speak of a large expenditure of money.

Drainage.

Although Greece impresses the visitor as an exceedingly dry country, there are several large marshy districts like that seen

in Fig. 9, and countless small, wet areas about wells, springs and irrigation channels which must be thoroughly drained to eliminate the mosquito and get rid of the malaria. This disease is a real scourge in some parts of Greece and represents perhaps the most serious public health problem there.

Some fifteen to twenty years ago, Lake Copais, in Bœotia, was drained by an English company and the bed of the lake, an area of about 100 square miles, was made available for agricul-



Fig. 9. Swamps on Melas River in Lake Copais Basin.

ture. The project as worked out requires pumping during the winter months to prevent flooding the bottom lands, and it has not been, it is said, altogether successful financially, a result which has tended to discourage similar ventures of this kind. It is of interest to note that when the English company uncovered the bottom of Lake Copais, they found evidences there of old villages and canals that may well have existed before the coming of the Greeks and which demonstrated that in the remote past the lake had been drained before. There are many other drainage projects in Greece awaiting attention, — one project, that of completing the draining Lake Stymphalia in the Peleponnesus

(Fig. 10), where Hercules performed the fifth labor. This project is said to have been originally carried out under the direction of Emperor Hadrian, but the tunnel driven in the second century becomes obstructed from time to time and must be enlarged and lined. The former government of Mr. Venizelos was considering, among other projects, the drainage of the swamps of the Vardar River in Macedonia, and an English firm submitted a proposal to make the necessary preliminary surveys and work



Fig 10. Lake Stymphalia.

out the plans for this improvement. In Macedonia there are other opportunities in which the government would like to interest capital. It was proposed in a report to former Premier Venizelos that the government should grant large areas of land there to foreign capitalists, with the understanding that they would drain, irrigate and farm these lands, and eventually dispose of them with the equipment to groups of peasant proprietors.

Irrigation.

The area of land under cultivation in Southern Greece can hardly be increased, as every patch of land capable of cultivation seems to be farmed. No water can be applied to most of the

land during the long rainless summers, and, except for the areas devoted to the culture of the vine and the olive, which need no irrigation, but one crop is grown each year, generally grain, which is sown late in the fall and harvested in July. Every drop of water from the summer flow of the springs and from many wells is now utilized, not always to the best advantage, as the free flooding of border method is generally used in handling the water. The problem is obviously to increase the amount of irrigable land by constructing storage reservoirs in which to carry over the winter rains that now, to a large extent, go to waste. There are some difficulties, however, in creating the necessary storage reservoirs, as the mountain valleys are generally steep and narrow, and the porous, seamy limestones of the country make the construction of tight reservoirs something of a problem. There are, however, to the writer's knowledge, a few very promising reservoir sites, and no doubt the physical difficulties of making tight reservoirs may be overcome.

In the Attica plain, water from the Cephisus is sold for irrigation at a price of 48 drachmas per strema (1,000 sq. melas) for a season's irrigation if twelve applications are made, which is equivalent to $37 per acre at normal rate of exchange. This gives some idea of the value of water in that country. Back in the country the water is owned and controlled by the small villages and only a nominal charge, if any, is made to cover the care and management of the ditches.

Roads.

Between the small city states of classic Greece, communications were poor and a system of cart roads over the entire country did not exist. Back in the mountains the writer has seen some excellent examples of ancient highway construction, of well-cut, irregular, polygonal blocks which happen to have been preserved through accident of drainage. Most of these old roads have been eroded and washed away because sufficient drainage was not originally provided, a fault in road construction that is still observable in modern Greece, and, indeed, not unknown in our own country. Most of the existing highways are of comparatively modern construction, and it is not clear just

why many of the mountain roads without gutters and adequate culverts do not entirely wash away during the winter. Certain it is that it is no pleasure to travel over them and, in the general absence of guard rails on bridges and steep mountain sides, it is not very safe to do so. A view of the road over Mt. Cithæron is seen in Fig. 11. The much despised Turk appears to have done not a little road-building in his time and has left some very creditable bridges, a form of construction in which the Greek of



Fig. 11. Road over Mt. Cithæron.

to-day, as in the past, does not appear to excel. One of these old bridges is shown in Fig. 12.

The large cities of Greece have some admirably paved streets, generally asphalt, but even in the cities and everywhere outside, with the exception of one short piece of road near Athens, the highways are surfaced with water-bound macadam, some of which is constantly being repaired and as quickly destroyed. Sometimes the destruction is the result of the torrential winter rains, but not infrequently it is done by heavy motor traffic, busses and trucks. I suppose that nowhere is the strain of eight years of war in Greece seen more clearly than in the neglect of their roads. Some important highways of macadam construc-

tion are now quite impassable, even with a Ford. In the vicinity of Athens there has been recently a large increase in the use of heavy motor busses to the surrounding towns, and that, with the automobiles and motor trucks, all driven at a pace that alarms the visitor, is destroying the roads more rapidly than they can be repaired. A road built of soft limestone rock, with a filler of sand and dust of the same material, cannot be expected to stand up long in the dry summer when it sometimes does not rain for weeks at a time.



Fig. 12. Old Turkish Bridge near Mt. Parnassus.

Some new road construction was being carried on by the government last fall through a contract with an English firm, one road near Athens, another back in the mountains. Both were being surfaced with water-bound macadam. No doubt, if the hopes of the Greeks are realized and oil is discovered in Greece, some improvement in the character of construction may be looked for.

Railroads and Canal.

Except for the Larissa railroad, running from Athens to Salonica and thence to Europe and Constantinople, all railroads

in Greece are narrow gauge. The Larissa railroad is of French construction and well built and operated, though, in common with all European roads, somewhat lighter than ours. A view at one of the stations on this road is seen in Fig. 13. The government proposes to acquire the railroads of the country, but the lack of funds will probably prevent this for some time. The railroads have been using English and American bituminous coal, some of it being briquetted to minimize waste. The only fuel available



FIG. 13. STATION AT DADI ON LARISSA RAILROAD.

in Greece is a very poor quality of lignite, but some success has been recently reported in briquetting this. The discovery of oil would mean much to the railroads.

The short railroad between Athens and Piræus, one of the best in the country, is electrified, and the government has plans for further electrification near Athens when other lines are acquired. All current for railroad, street cars, lighting and commercial uses in the vicinity of Athens comes from a steam plant near Piræus.

Greece has one very famous canal, that crosses the Isthmus of Corinth, which connects the Gulf of Corinth with the Saro-

nic Gulf. The ancients considered the project of a canal across the Isthmus, and some traces of the work done under the Emperor Nero may still be seen. Little was accomplished. They had to content themselves with a small ship railway. Not until 1881 was the excavation of a canal seriously undertaken again by a French company and finally finished by the Greeks some ten



FIG. 14. CORINTH CANAL.

years later. A view of the canal from the railroad and highway bridge over it is shown in Fig. 14. The total length of the canal is $3\frac{1}{2}$ miles, of which one mile is in rock. The waterway is 100 ft. wide and 26 ft. in depth, only sufficient for small vessels.

The channel of the Euripus at Chalkis, between the island of Eubœa and the mainland of Bœotia, though not a canal, is a very important channel for small craft. It has recently been widened and made safe for navigation.

Hydroelectric Power.

Hydraulic power is very generally used in Greece for grinding grain and for rug-beating. One of the water wheels which is typical of those seen throughout the country is shown in Fig. 15. There are very few hydroelectric plants. One near the city of Lamia that came within the writer's knowledge represented a



FIG. 15. WATER WHEEL NEAR SOUVALA.

very incomplete development of a stream fed by high mountain springs. This was an Italian development and the power was used largely at an adjacent carbide plant. Macedonia offers a large field for hydroelectric development, and a report is now being made by a Greek group with foreign backing, supposedly with a view to obtaining a concession.

Port Improvements.

The foreign commerce of Greece is greatly hampered by inadequate port facilities. Improvements are proposed by the

government at Piræus, Kavala, Dedeaghatch and other ports. The need of improvements at the harbor of Piræus is great. The delays in getting freight through this port are almost unbelievable. At least a month is generally required, however urgent is the need for goods or equipment. All ships lie out in the harbor and all goods are lightered. Every one of many transfers between the ship and the customhouse means a fee for some of the army of port workers.

Three English firms submitted plans and proposals last fall for the construction of an extensive system of docks in the harbor, the period of construction to cover a number of years, so as not to interfere unduly with traffic. No award has been made by the present government as far as known.

Construction Conditions.

Greece is a poor country, with few natural resources upon which to build a large program of public improvements. The lack of money for public works is no new thing in Greece; in ancient times, the Athenians had difficulty in making both ends meet. It must be recalled that, in the time of Pericles, Athens exhausted her modest resources in building the Parthenon and did not finish the group of buildings planned for the Acropolis. Some of the money used for this magnificent work represented contributions from her allies for making war against Persia, and was perhaps improperly used in spending it to beautify Athens. Whatever may have been the justice of this financial program, this was at least one case where the end justified the means. If Greece now succeeds in retaining the rich lands in Thrace and the Smyrna hinterland which were awarded by the treaty of Sèvres, the government will some day, according to former Premier Venizelos, have a very handsome national income, but, for the present, foreign assistance is evidently needed for carrying on public improvements.

Concessions.

For most public works the declared policy of the government under the Venizelos régime was to require the contractor seeking

to do public works to furnish at least 50 per cent. of the capital required. Not only would such a plan conserve the financial resources of Greece, but it would tend to keep the wealth of the country at home. It has been the practice of the government in providing security for a foreign loan to pledge certain public revenues to insure the payment of principal and interest. In granting a concession covering a period of operation of public utilities the policy of the government appears to be to insist on the control of the enterprise by Greek citizens.

Materials of Construction.

Except for stone, cement, possibly brick and a little lumber, all materials, machinery, tools and other equipment must be imported. No really good brick is made in Greece except some sand-lime brick for building, but there is no reason, with the materials available, why excellent brick and good vitrified pipe could not be made. Disregarding the expensive marbles, practically nothing but limestone is available as a building stone in Southern Greece, but this is a good serviceable material. The most serious problem there is to find any suitable sand for mortar or concrete. The sand commonly used is that found in small quantities in the stream channels or on the beaches. This sand is very largely limestone, and to our eyes a very poor material, but it has been successfully used for even hydraulic construction. For a large job, such sources would not furnish enough sand and some other solution of the sand problem would have to be developed. Possibly limestone crushed and rolled would give a satisfactory product. Two cement mills near Athens, one at Piræus and another at Eleusis, turn out a satisfactory Portland cement, and sufficient capacity may be developed in these mills for the largest construction project.

Trees in many sections of Southern Greece are conspicuous by their absence. The pine is the most common, but this is useless for lumber and would hardly answer for temporary timbering in tunnels. It is gashed ruthlessly to obtain the resin with which to preserve and flavor the native wine, and then it falls a victim to the woodchopper. The ubiquitous goat effectively prevents any new growth. The oak, which in ancient days was

important for shipbuilding, is seldom seen, and other trees, such as the sycamore and the plane, are not plentiful and have little value. A little fir has been cut back in the high mountains, but practically all lumber required in the country is imported.

Construction Superintendence.

There are many able Greek engineers largely educated in France and Germany, but few with much experience on large public works construction. Any large project would therefore require foreign engineers, and the same is true of skilled superintendents and foremen for most work. It is of interest to note that the ministry of communications employed forty Swiss engineers last year.

Labor.

There is apparently no dearth of skilled labor, such as employed in the building trades. Steel workers need not of course be looked for. Only one steel frame building exists in Athens; most buildings are of masonry of massive design, rather poorly bonded and uniformly stuccoed to give the appearance of smooth cut stone. A few reinforced concrete buildings are being constructed in Athens, and satisfactory work is being done.

A serious difficulty in constructing large public works in Greece would be to find sufficient unskilled labor, and it would be necessary to import it. There is no surplus native common labor and wages are relatively high, about 300 per cent. of the pre-war scale. While a surprising number of Greeks have been in this country and speak an unmistakable American variety of English, the language difficulty would stand in the way of rapidly organizing a job under skilled American foremen. The output of labor, both skilled and unskilled, in Greece, is low. No one seems to be in a hurry. "Avrion," the manana of that country, is the appointed time for doing all things. Of course, the hot summer climate and the malaria discourage any continued and strenuous effort during the working season, and the most energetic of Americans would not do as much during the second summer as he did during the first.

American Opportunities.

In these times when so many American engineers find little to do at home, they may have to follow the example of the English and find increasing employment in foreign fields. In Europe, at least, we need not anticipate large opportunities unless American capital is more largely invested there. At present our people do not apparently care to invest their money abroad, and I fear we do not know how to go about it, anyway. The English make large foreign investments and seem to understand better than others how to obtain concessions. They do not seem to be afraid to spend their money abroad through fear of not being able to get it back. It seems to be well understood abroad that the English government does not hesitate to use all its influence to see that its citizens receive substantial justice, and that they therefore receive many privileges and opportunities denied to other nationals. The writer was credibly informed that the proposals on one project in Greece were restricted to English firms, and even had there been American firms interested in the project, they would have been excluded from the competition. In spite of the objections raised in high places a few years ago to "dollar diplomacy," our representatives abroad will have to practice some such diplomacy as this unfortunate phrase describes if American financiers and American engineers and contractors are going to have their share of the business in undeveloped foreign countries.

MEMOIRS OF DECEASED MEMBERS.

JAMES C. SCORGIE.*

James C. Scorgie was born in Aberdeen, Scotland, on August 2, 1850, the son of George and Helen Scorgie. He married Miss Anna Monson of Cambridge, and is survived by his wife and three daughters, Miss Anna Scorgie, Dr. Helen Scorgie and Miss Elvira Scorgie.

He died at St. Elizabeth's Hospital, Brighton, February 16, 1921, where he underwent an operation.

From his earliest school days at Aberdeen he evidenced exceptional ability in mathematics, and this led to his taking up work as a young man, with the Harbor Board, in the Paymaster's and Engineering departments, in which he assisted, as his first engineering experience, in the building of a breakwater at Aberdeen.

He came to this country in 1873 and began work in Cambridge as draughtsman and engineer for the largest granite builders in this vicinity. The erection of the State Insane Asylum at Worcester, Mass., and the Reformatory at Concord, Mass., were the larger buildings in which he assisted.

In 1880 he accepted the position of surveyor and engineer at Mt. Auburn Cemetery, later serving as Assistant Superintendent and then Superintendent, a continuous service of over forty years.

Mr. Scorgie was made Superintendent in 1896 and held that position at the time of his death. He was honored as one of the best informed men in his profession and a leader in the discussions and counsels of the Association of American Cemetery Superintendents, of which he was a member from its inception.

A natural student, he improved himself by the study of engineering during his spare time, and also took some special

* Memoir prepared by John F. Peterson.

courses at Harvard and the Massachusetts Institute of Technology. His ability as a landscape engineer and his knowledge of horticulture is amply reflected to the visitors of Mt. Auburn Cemetery, and will be for years to come, as in this particular work the engineer rarely lives to see the completion of the picture which he builds for future generations.

Mr. Scorgie designed and superintended the construction of a large concrete boundary wall on the western side of the cemetery, almost half a mile in length. He held the full confidence of his trustees and coworkers, and brought about numerous important improvements. He was the first to build bituminous roadways in cemeteries, and built up and enlarged a complete water supply for the cemetery, including pumping station, filter beds and necessary equipment to go with it; the administration building, chapel and crematory were built while he was Superintendent. These and all the necessary equipment for the best conduct of a cemetery were constantly receiving his study and attention, so that, to-day, Mt. Auburn Cemetery stands as the best equipped unit in this particular field.

He belonged to many societies and social organizations, including the American Society of Civil Engineers, the Boston Society of Civil Engineers, the Massachusetts Highway Association, the American Society of Cemetery Superintendents, the New England Society of Cemetery Superintendents, the Massachusetts Horticultural Society, the Horticultural Club of Boston, the Scots' Charitable Society of Boston, the Boston Scottish Society, and the Cambridge Club. He was a Mason and a Granger, and his chief interest in the past few years was his membership in the Unitarian Laymen's League, as he was interested in Cambridge as well as at his summer home in Harvard, Mass.

Mr. Scorgie was a student up to the day of his passing. He possessed a library rarely found in a private home. A man of sterling qualities, strong character and attractive personality, he leaves the community not only indebted for the work he accomplished, but for the very many pleasant and interesting interviews he gave to those who were fortunate enough to come in contact with him.

DAVID HERBERT ANDREWS.*

David Herbert Andrews was born in Pepperell, Mass., September 17, 1844, his father being the minister of the Congregational Church. He died at his home in Newton Center, Mass., on February 24, 1921.

Mr. Andrews was obliged to earn his own living early in life, and his natural inclinations led him to employment with machine shops in Worcester and Fitchburg. Believing a college education would be of great advantage to him, he prepared himself by night study to enter the Chandler School of Science and the Arts connected with Dartmouth College, graduating therefrom with the degree of Bachelor of Science in 1869. In 1908 he was given the Honorary Degree of Master of Arts by the same institution. Always greatly interested in the welfare of his alma mater, he was appointed in 1896 a member of the Board of Visitors of the Chandler Foundation and continued to serve in this position until his death.

After graduating from college he taught mechanical drawing in a night school at Fall River, Mass., later entered the employ, in the engineering department, of the National Bridge and Iron Works, situated in East Boston, Mass. As their engineer, he began a career notable for its part in developing the art of construction in iron and steel, then in its infancy, but destined to become one of the triumphs of American engineering. The pioneers in this industry were venturing in a new field with new materials, requiring new machinery and methods of manufacture and erection. They were called upon to design as well as construct, and they developed the theory as well as the practice of structural engineering.

An interesting example of the work designed by Mr. Andrews while with the National Bridge and Iron Works was the Boston train shed of the Boston and Lowell Railroad, afterwards incorporated as part of the North Station and finally removed in 1920, after forty-eight years of service. In 1872, at the time this shed was designed, the graphical systems of plotting the stresses in braced arches were not practically developed in this country, and

* Memoir prepared by John C. Moses and J. Parker Snow.

the necessary computations for the arches of this roof were made from a study of a catenary chain distorted by weights hung over sheaves. The building of this shed caused considerable interest in engineering circles at the time and the structure when built was the most noted building of its kind in the country.

The National Bridge and Iron Works met with financial difficulties and its affairs were wound up by receivers in 1876. Mr. Andrews bought the tools and machinery with borrowed money and founded the Boston Bridge Works, with its shop in East Cambridge, Mass. As its sole proprietor he now proved himself a business man of great ability, soon achieving financial success as well as a wide reputation for the workmanship of his structures, a large proportion of which were also designed by him and his engineers. This reputation and success were founded upon his industry, strict attention to business and to the confidence that he inspired in every one — employees, capitalists, supply firms and customers — of his entire reliability and strict integrity. A list of the work done during the first twenty years would comprise most of the railroad and highway bridges of New England and a considerable number in other parts of the country. The first steel buildings in Boston would also be included. His talent for invention produced the first derrick car for bridge erection in the early eighties, and a new type of locomotive turntable that is still in wide use. His plant was completely destroyed by fire in 1896, but, not discouraged, he immediately started plans to rebuild, and after personally making a study of the best plants in the country, he designed his new factory and supervised its construction in every detail. In 1901 he incorporated The Boston Bridge Works, remaining its president until his death and being succeeded in that office by his son, John G. Andrews.

Mr Andrews' professional and business life covered a period of fifty years, during which time the use of iron and steel increased many fold. It required courage and industry, technical skill and practical common-sense to succeed in the early days, and this record is made as an example and encouragement for those who now take up the work that has been begun for them.

Mr. Andrews served as Chairman of the Chelsea School Board during his residence in that city. He moved to Newton Center in 1890 and took an active part in the church and civic affairs of that community. He was elected a member of the Boston Society of Civil Engineers in 1881, and was a member of the Engineers Club of Boston. He was also a member of the American Society of Civil Engineers, American Society of Mechanical Engineers, the Boston City Club, and of other civic and social organizations.

Mr. Andrews was married in 1872 to Miss Clara Gilbert, of Concord, N. H., who survives him, as do also a daughter and three sons, two of the latter having been long associated with their father in his business.

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PAPERS AND DISCUSSIONS

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INVERTED SIPHONS FOR SEWERS
FINAL REPORT OF COMMITTEE

TABLE OF CONTENTS.

REPORT ON INVERTED SIPHONS.

General Features.
Reasons for Installing.
Material. Limiting Size.
Development of Use.
Conditions Affecting Design.
Desirable and Actual Velocities.
Hydraulic Principles.
Profile.
Screens. Settling Chambers. Sumps.
Methods of Cleaning.
Stoppages.
Multiple Pipes.
Buoyancy. Ventilation.
Important Principles.

APPENDIX A.— Data Relating to Inverted Siphons in Massachusetts.

APPENDIX B.— Analysis of Data Received Relating to Inverted Siphons in Massachusetts.

APPENDIX C.— Detailed Descriptions of Certain Inverted Siphons in Massachusetts.
Amesbury, Mass.
Andover, Mass.
Easthampton, Mass.
Gardner, Mass. (3).
Fitchburg, Mass.

Appendix D.— Data Relating to Certain Inverted Siphons Outside of Massachusetts.

Appendix E.— Notes Relating to Certain Inverted Siphons Outside of Massachusetts.

Aberdeen, Scotland.
Paris, France.
Buenos Aires, Argentina.
Binghamton, New York.
Carlisle, Pa.
Chicago, Ill.
Hattiesburg, Miss.
Louisville, Ky.
Milwaukee, Wis.
New Jersey Joint Outlet.
New Orleans, La.
Philadelphia, Pa.
St. Louis, Mo.
Syracuse, N. Y.
Waterbury, Conn.

Appendix F.— References.

July 16, 1921.

To the Sanitary Section of the
Boston Society of Civil Engineers:

Your Committee on Inverted Siphons for Sewers begs to report as follows:

The original committee, consisting of W. S. Johnson, R. M. Whittet and D. Porter, was appointed February 3, 1915, to study and report upon "Methods of Design and Construction, and Results of Operation of Inverted Siphons for Carrying Sewage only and for Storm Water."

In March, 1915, preliminary inquiries were sent to various Massachusetts town authorities to learn on what sewer systems inverted siphons were in use. Guided by information thus obtained, blanks were forwarded in April asking for certain descriptive details of each siphon and for data regarding its maintenance. Similar requests were also sent to a number of city engineers and engineers in private practice in New England cities outside of Massachusetts. More or less complete information was secured

for upwards of 90 siphons, with blue-prints for a considerable number of them. Use has also since been made of material found in sundry engineering publications, and by recent additional inquiries, accompanied by blanks, the total number of inverted siphons covered has been increased to about 140.

The data obtained on the earlier blanks were partially arranged later for informal presentation at a meeting of the Sanitary Section held April 5, 1916, which was participated in by half a dozen or more of our members and devoted to a discussion of their experience with the design or maintenance of inverted siphons.

Mr. Johnson, as Chairman of the Committee, then took in hand the papers in the case for the purpose of drafting a formal report, but died October 27, 1917. Mr. Whittet followed as Chairman and intended to prepare the Committee's report, but he died December 10, 1918. What progress, if any, either of these gentlemen made with a report it has been impossible to learn, and none of the original blue-prints or sketches furnished to the Committee can now be found. Nevertheless, the material in hand recorded on the blank forms was thought to warrant presentation, and June 12, 1920, the Committee was reconstituted, to consist of D. Porter, F. A. Marston and H. E. Holmes.

The blanks sent out in April, 1915, called for the following information:

Name of town and location of inverted siphons.
Whether on separate or combined system.
Date of construction, material, and number of lines.
Diameter, and length on axis.
Elevation of invert at upper end, lower end, and lowest point.
Size and slope of sewer at upper and lower ends of inverted siphon.
Provision in the way of blow-off, overflow or sump.
Method, if any, provided for flushing.
Other methods provided for cleaning.
Names of designing engineer, of person having charge of maintenance, and of person submitting information.
Sketch plans and profiles.
Frequency of flushing, or of cleaning by other means.
Cases of complete stoppage and how dealt with.
Whether or not siphons are flushed oftener than main system.
Cost of cleaning.

The following report will present in outline the principles and practice relating to inverted siphons brought out by the Committee's investigation, followed by six appendices which give, successively, a tabulation of data relating to inverted siphons in Massachusetts, an analysis of those data, detailed descriptions of certain inverted siphons in Massachusetts, data and notes relating to certain inverted siphons outside of Massachusetts, and selected references, to numerous of which allusion is made in the body of the report. The accompanying drawings illustrate some types of inverted siphons which have been constructed.

Through misinterpretation of questions or answers and in other ways errors are liable to enter work of this sort, but due care has been taken to secure accuracy and it is believed that the general statements are substantially correct.

General Features.— An inverted siphon is here to be understood as simply a dip or sag introduced into a sewer, which above and below is normally running but partly full and, generally speaking, with but moderate slope. It is illustrated on a small scale by the common running trap on the main drain of a house. Its name suggests its general shape in profile, but otherwise has no warrant, and may mislead into the thought that in some way the distinguishing hydraulic principle of the true siphon is involved, which is not the case. With either the true siphon or the so-called inverted siphon there must be a drop from the inflow water surface to the outlet if there is to be any flow. The length may be indefinitely great. Some of the inverted siphons on city sewers are less than ten feet in length, while several of those built in Massachusetts, in order to reach certain filtration areas, are some thousands of feet long. That built on the outfall line of the Boston Main Drainage Works, between the pumping station and Squantum, conveying sewage under Dorchester Bay, has a length of 7 160 ft. It is 7.5 ft. in inside diameter, averages 142 ft. below low tide, and is conspicuously the longest, largest and deepest inverted siphon in the state. It is also apparently the oldest. What is asserted to be the largest in the United States is that which has recently been built to convey the sewage of New Orleans under the Industrial Canal; it is

10 ft. in diameter, and has a nominal carrying capacity of 2 000 cu. ft. per second. (*Scientific American*, 1920.)

Reasons for Installing.— Occasion for the use of an inverted siphon arises where a sewer encounters another conduit, subway or other underground structure, a stream or a valley, and where it can be carried underneath with far less expense than is involved in any other solution of the problem. An example is afforded by the case of the Lexington Avenue subway in Manhattan, which required inverted siphons at 106th and 110th Streets. These could have been avoided either by lowering the subway for some eight city blocks so as to pass under the sewers, or by building a new trunk sewer in Park Avenue. The former expedient, however, was estimated to increase the cost of subway construction probably a million dollars, besides unfavorably affecting the depth or location of stations, while the new trunk sewer with necessary laterals would have cost probably over a million and a half. The estimated cost of the two inverted siphons, which were finished in 1912, was $71 000. (Wilson, 1913.)

Material. Limiting Size.— Generally, though not always, the depression at an inverted siphon is sufficient so that the pipe flows with full cross-section and under more or less of a bursting pressure, which it must of course be designed to withstand. In many cases this is so small that a clay sewer pipe can be used with considerable safety, especially if reinforced with concrete, but in a decided majority of the siphons in this state the pipes are of cast iron. Next to that of the Dorchester Bay inverted siphon, the greatest dip reported* is that of the one at Andover, the low point of which is 53.5 ft. below the water surface at the outlet.

Practical considerations, such as the increased danger of stoppage in small pipes, tend to fix the minimum diameters for inverted siphons about as for ordinary sewers,— 6 or 8 in. in the separate system and say 12 in. in the combined system, although there are rare examples of smaller sizes.

Development of Use.— The use of metal inverted siphons of large diameter and under relatively high pressure has been practicable since the introduction of iron pipes about 1 700, but

* In Massachusetts.

in sewer practice the device appears not to be old. It was employed more than forty years ago by the eminent English sanitary engineer, Baldwin Latham, who designed six large wrought-iron siphons for the sewerage system of Dantzic, for crossing the Vistula and certain of its tributaries. The earliest example reported to us in this state was that of an 8-in. iron siphon under the Spicket river, on Hampshire Street, Lawrence, built in 1885, although the brick-lined tunnel which forms the inverted siphon under Dorchester Bay was completed two years earlier.

Inverted siphons are not uncommon on pipe lines for water-supply, water-power and irrigation in which nominally clear water is conveyed; but they have been employed on sewers with considerable reluctance, through fear of clogging by foul matter carried in suspension, or by grit rolled along the sewer invert. This reluctance has been naturally and especially felt in the case of combined sewers, with their great fluctuations in volume and their load of débris derived from the streets. The 110th Street inverted siphon under the Lexington Avenue subway, in Manhattan, completed in 1913, is said to have been advised against by two of the most eminent authorities on sewer construction. There the approaching sewer is 10 ft. by 12 ft. in size, "and if the siphon should become choked in a storm it would flood 50 acres of buildings." (Wilson, 1913.) However, this siphon was built, and has given no trouble. It is safe to say that engineers have been generally agreed that inverted siphons should only be employed on sewer lines as a final alternative, where other methods of avoiding an obstruction would be either impracticable or costly. Nevertheless, there has been abundant experience to show that if well designed and looked after they rarely become dangerously clogged and are not unduly expensive to maintain. Emphasis must be placed, however, on the importance of systematic and careful inspection and the prompt removal of obstructions before they form a serious barrier.

Conditions Affecting Design.— There are two distinct conditions under which inverted siphons are adopted, and these have a marked bearing on the ease or difficulty of the problem in a particular case. First, one may be introduced as a feature

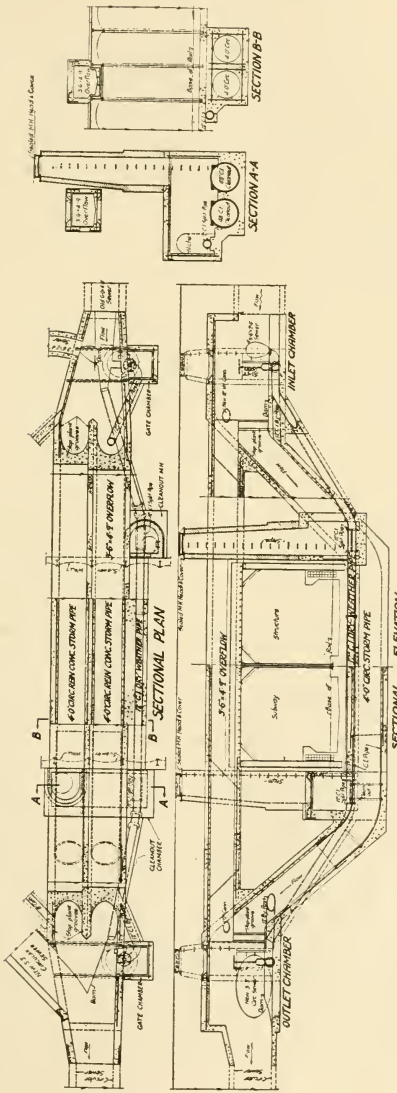


FIG. 1. — INVERTED SIPHON AT MARTENSE ST. AND NOSTRAND AVE., BROOKLYN, N. Y.

foreseen in the original design of a new sewer line; second, it may become necessary to insert one in an old sewer because of the building of some underground structure crossing its course. In the case of the new sewer the designer may presumably provide in advance the necessary drop in the hydraulic gradient for the satisfactory operation of the siphon without causing backwater upstream. But in the case of an old sewer, unless a readjustment of its profile is practicable, the drop will have to be automatically developed by a rise in the water surface upstream, with a resulting increased tendency to deposits there. Many examples of this class have arisen in the larger cities on important sewers of flat slope, conspicuously in connection with subway construction. The first inverted siphon made necessary by New York City subway requirements was built in the Bronx, at 149th Street and Railroad Avenue, and went into service in February, 1902. Nearly a score of others have since been added, the majority in Brooklyn.

Since the principal consideration in the design of inverted siphons for sewers is the prevention of deposits, and since these most easily develop where the foreign matter transported is relatively abundant and heavy, it is seen that the problem varies in character with the type of sewage. That in combined systems is most troublesome, because it comprises a foul domestic and industrial sewage in dry weather, and in storms a vastly larger volume of surface water, bringing with it grit and miscellaneous débris. The dry weather sewage, or that carried at all times in the small pipes of the separate system, has mainly organic matter in suspension, which can be kept moving by very moderate velocities; although in some cases it contains considerable grit which has entered through perforated manhole covers, and other articles mischievously introduced at such points. Exclusively, storm sewers, or drains, have the large variations in flow shown by combined sewers, but are free from the dry-weather flow of foul domestic sewage. Intercepting sewers offer the favorable feature that their flow is mainly of domestic and industrial sewage and tolerably uniform in volume. In the exceptional cases in which inverted siphons are needed on the effluent lines from sewage-treatment plants the conditions are the most favor-

Details of Inverted Siphons under New York City Subways

Location.	Size and No. of Pipes.		Capacity of Pipes. Cu. Ft. Per Sec.		Total Hor'l Length, including Chambers, in Feet.	Depression of Pipes below Grade Line, Feet.	Diff. of Inv. Elev. of Chambers, in Feet.	Estim. Cost.	Date Completed.
	Storm.	Sanitary.	Storm.	Sanitary.					
149th St. and R.R. Ave., Bx.	2–42″	1–14″	120	6.0	66	9.3	0.1	$6 000	Feb. 1, 1902
Fulton St. and Hudson Ave., B'klyn	2–24″	1–10″	45	2.52	141	22.0	0.6	8 500	Jan. 3, 1914
4th Ave. and Dean St., B'klyn	2–48″	1–18″	266	11.0	135	13.7	0.9	11 100	July 8, 1911
4th Ave. and Butler St., B'klyn	2–101″	1–16″	680	12.0	100	19.5	0.1 & 0.9	11 900	Aug. 17, 1912
4th Ave. and 7th St., B'klyn	2–72″	1–30″	330	25.0	82	3.4	3.0	4 700	Nov. 25, 1911
4th Ave. and 26th St., B'klyn	2–54″	1–24″	160	15.0	104	2.3	1.1	5 500	Jan. 27, 1912
4th Ave. and 35th St., B'klyn	1–24″	1–6″	19	1.2	117	12.1	1.5	3 800	Sept. 21, 1912
Lex. Ave. and 106th St., Man.	2–48″	1–24″	80	9.8	159	13.8	0.15+	19 000	Oct. 19, 1912
Lex. Ave. and 110th St., Man.	2–78″	1–42″	356	19.6	256	15.5	0.26+	52 000	Jan. 7, 1913
So. Boulevard and 144th St., Bx.	2–30″	1–8 ″	50	0.9	115	15.4	1.0	4 000	.....
So. Boulevard and Longwood Ave., Bx.	2–30″	1–8 ″	61	0.65	134	11.7	3.5	5 000	.....
So. Boulevard and 149th St., Bx.	2–48″	1–14″	225	6.5	83	11.3	0.83+	11 000	.....
65th St., bet. 21st and 22nd Aves., Bx.	1–16″	1–8 ″	68	0.8	162	10.4	0.66	2 100	Sept. 22, 1914
20th Ave., bet. 63rd and 64th Sts., Bx.	1–24″	1–8 ″	14	0.7	137	11.4	0.45	1 500	Aug. 20, 1914
7th Ave., at 18th St., Man.	2–60″	1–24″	360	20.	212	8.2	0.65	18 000	.....
Nostrand Ave. and Martense St., Bx.	2–48″	1–12″	68	1.36	102	14.48	0.07	8 200*	.....
Nostrand Ave. and Clarendon Rd., Bx.	2–36″	....	49	0.74	86	14.25	0.13	4 200*	.....
Nostrand Ave. and Farragut Rd., Bx.	2–63″	1–20″	263	6.82	124	12.75	0.10	9 400	.....
Nostrand Ave. and Foster Ave., Bx.	2–54″	....	144	....	99	18.56	0.10	4 200	.....
Nostrand Ave. and Beverly Rd., Bx.	2–54″	1–14″	153	2.84	152	15.85	0.50	6 400*	.....

* Includes cost of overflow.

able of all, since the liquid approximates more or less closely to clear water.

Desirable and Actual Velocities.— A serious obstruction being more difficult to remove from an inverted siphon than from an ordinary sewer, especial care should be taken to prevent its formation. The design, therefore, should aim to insure at all times at least as high a velocity through the siphon as would be considered necessary to prevent deposits in the approaching sewer,— say from 2 to 3 ft. per second for domestic sewage, and 3 or more ft. per second for combined sewage. If it is impracticable in a particular case to provide head for such velocities, then correspondingly greater reliance must be placed on artificial flushing or other means of cleaning the siphon.

Comparatively few data are available regarding velocities actually prevailing in inverted siphons. Mr. J. L. Woodfall has given the average velocity in the Gardner, Mass., siphon, built in 1890, as about 0.4 ft. per second in 1904, and yet, in spite of this low value, flushing had not been thought necessary for several years. (Bos. Soc. C. E., 1904.) For the Gardner siphon built in 1900, Mr. Woodfall gave the average velocity, in 1904, at about 0.3 ft. per second, and for the siphon for Andover, Mass., 0.25 ft. per second. None of these carried storm water.

In an article in *Engineering and Contracting*, July 15, 1914, Mr. F. H. Carter gave the following range in velocities in inverted siphons on the Metropolitan main sewers in the vicinity of Boston:

Shirley Gut	1.92 — 2.70 ft. per sec.
Chelsea Creek, East Boston	2.31 — 3.25 ft. per sec.
Malden River	1.19 — 3.49 ft. per sec.
Mystic River, Boston	1.54 — 2.99 ft. per sec.
Aberjona River, Medford	1.80 — 2.82 ft. per sec.

Hydraulic Principles.— The actual velocity of flow in ft. per second through the pressure pipe of the inverted siphon, which in most cases has sufficient sag to flow full, will of course be equal at any time to the actual volume of flow in cu. ft. per second, divided by the area in sq. ft. of the internal cross-section. In designing, the volume to be anticipated must be estimated as

for any sewer, or in case the siphon is to be introduced into an existing sewer, the known or computed discharging capacity of the latter may be thought proper to use. The volume divided by the value it is decided to assume as a reasonable minimum velocity gives the necessary area of cross-section of pressure pipe, which may be approximated by the selection of a suitable commercial diameter.

The total head (H, see Fig. 2) or drop in the hydraulic gradient actually required at any time for the then-existing flow will be the difference in level of the free-water surfaces at

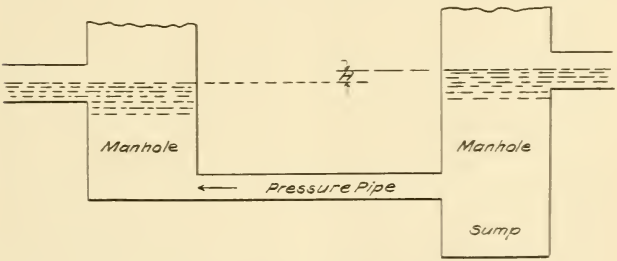


FIG. 2. — OUTLINE OF SIPHON SHOWING WORKING HEAD AND AVAILABLE HEAD.

the two ends of the siphon. It will equal the sum of the friction head, as determined by the actual length of the siphon measured along its axis, the head lost at any bends, and that lost by any abrupt changes of cross-section, as at entrance from an upstream manhole into the pressure pipe, or from the pressure pipe into a downstream manhole. Theoretically, it may also in some cases cover a small value, plus or minus according to circumstances, due to difference of velocity heads in the approaching and departing sewers. The determination will be parallel to that for any similar conduit carrying clean water, but the friction loss is likely to be increased a varying and uncertain amount by the more or less foul condition of the interior of the pressure pipe, and a serious local obstruction in that pipe may cause, while it lasts, a relatively large loss of head of indefinite size. Losses

of head due to bends and changes of cross-section are difficult to estimate closely. Those caused by bends alone are likely to be trifling with low velocities, and may be diminished by using curved elbows. Those accompanying a square-edged entrance from an upstream manhole into the pressure pipe are more important, but may be reduced by rounded edges or a flaring entrance. On the whole, it seems wise to be liberal in estimates of total loss of head. It is to be remembered that the losses will be relatively small for low velocities, other things equal, but that they increase roughly as the square of the velocity. For a siphon of the type illustrated in Fig. 2, with a clean 12-in. iron pressure pipe 50 ft. long, and a velocity nowhere exceeding 3 ft. per second, a total loss of head of 6 in. would probably be an outside value; for a velocity of 2 ft. per second, 3 in.; but for 6 ft. per second, 24 in. The friction loss alone in this case would be not over one-fourth the above values.

The head offered by the construction of the inverted siphon will in general be about the difference of level of the inverts of the approaching and departing sewer at the ends of the structure. If the condition of flow demands at any time a greater head than this, it will be automatically built up by the sewage itself, through a rise of level in the upper sewer, with a corresponding slackening of the velocity there. This may be objectionable.

Since the volume of flow is bound to be more or less variable, the actual total head (H) to meet the losses in the inverted siphon must also vary. It will change from hour to hour, and will also increase year by year as the tributary drainage district becomes more developed and its sewage or storm-water discharge becomes greater. As time goes on, if the increased head thus required is not available, relief may be had by building, or putting into commission if already built, one or more additional lines of pipe. This provision is frequently made at the start for inverted siphons taking sewage from a combined system, the best practice reserving one of the pipes exclusively for dry-weather flow.

Interesting experiments have been cited by J. L. Woodfall (Bos. Soc. C. E., 1904), as having been made by the Massachusetts State Board of Health on the Gardner inverted siphon built

in 1890. These showed actual losses of head, after flushing, varying under two different rates of flow from about 1.9 to about 2.2 times the loss computed as theoretically correct for a clean pipe. Before flushing, and some seven months after the last previous flushing, the measured loss of head was roughly 3.5 times that computed for clean water in a clean pipe. This was a 12-inch iron pipe, 1 050 ft. long.

Profile.— The longitudinal profile adopted for an inverted siphon will be influenced in part by the profile of the surface under which it passes, in part by the nature and position of underground structures which the siphon is built to avoid, or of the material to be encountered, and in part by a desire to make it so far as possible self-cleansing. If it passes under a stream, or a valley, it is likely to show inclines at the two ends joined by a relatively flat section. If of short length, as in passing under another conduit in a cross street, it often consists of a vertical well or manhole at each end, with a straight connecting pressure pipe, having more or less grade toward the well at which pumping is proposed to be done in emptying and cleaning the pipe. Where the water carries heavy matter in suspension or rolled along the sewer bottom, as in the case of storm flow, an upward slope at the downstream end is more favorable than a vertical rise for carrying the grit out of the siphon. In cases where there is but scanty head available and its conservance is important for avoiding back-water upstream, inclines at the ends involve somewhat less loss of head than vertical wells. Inclines are a feature of all the inverted siphons used on the combined sewers intersected by the New York City subways, with the exception of that at Hudson Avenue, Brooklyn. There one leg of the siphon had to be constructed in a limited space between the walls of the old and the new subway, and was made vertical.

Screens, Settling Chambers, Sumps.— The subsidiary features of inverted siphons are mainly aimed at intercepting material which might clog the pressure pipe, or at providing for the efficient cleaning of the pipe if it should become fouled or obstructed. In substantially all cases there is a manhole at each end of the siphon, providing access for inspection and cleaning. It is

possible for clogging material to be held back from the siphon by screens or settling chambers. Screens appear to be used but very exceptionally, unless for the protection of neighboring pumps. Such an arrangement is described by Baldwin Latham for the inlets of the inverted siphons at Dantzic, conveying sewage under two navigable channels to the pumping station, which is located on an island. Boston sewage is screened before reaching the siphon under Dorchester Bay, but the screens are above the pumping station. The upper end of the Andover, Mass., inverted siphon starts from a screen chamber intended to remove large solid matter; and just above the Commercial Street siphon under the Lechmere Canal, in Cambridge, there is a bar screen, which is regularly examined and cleaned. During the construction of the Brooklyn inverted siphons made necessary by subway work the use of bar screens above siphon entrances, to keep out large floating materials, was considered, and to test its practicability a temporary wooden screen was set up in a large sewer leading to one of the siphons. Within two days "it was completely covered for the depth of the flow with rags, paper, twine, wood and other débris, effectively blocking the flow, and showing conclusively that any such device would form a dam in a very short time. Mechanically rotated screens, such as are used in sewage purification plants, would serve the purpose, but could not be used owing to the cost of maintenance." (Hunt, April, 1917.)

Heavy matter can be intercepted by settling. If such provision is made it logically should be at or near the upstream end of the inverted siphon. Also, unless very frequent removal of the deposit can be relied upon, the settling chamber needs to be of considerable size, else it may soon become filled and no longer serve its purpose. In numerous cases in this state the upstream manhole is continued below the entrance to the pressure pipe so as to form a sump. Ordinarily this appears to be not more than two or three ft. deep. It may be convenient if the siphon has to be pumped out, and useful as an intercepter of pieces of brick, stone or metal, but merely as a silt-catcher its value seems to be open to question. There is a wide difference in practice regarding the employment of sumps. On 16

inverted siphons for which returns were received by this Committee sumps are provided at the upstream end, on 32 at the downstream end, on 17 at both ends, and on 58 at neither end. The first inverted siphon built because of New York subway construction, that at 149th Street and Railroad Avenue, had a sump at the upstream end, but after seven years of experience with it the engineers of the Public Service Commission recommended its omission from subsequent designs, as being unnecessary. (Hunt, April, 1917.)

Some 1 500 ft. above the head of the inverted siphon on the main sewer from Fitchburg, Mass., to the sewage treatment plant, there is a grit chamber about 50 ft. long, designed to intercept grit larger than $\frac{1}{16}$ in. in diameter.

At the head of the inverted siphon under Dorchester Bay, on the Boston Main Drainage system, there is a settling chamber, in the form of twin "deposit sewers," 1 260 ft. long, arranged to insure a velocity not exceeding 1 ft. per second.

In their report on The Riverbank Subway (1909), Kuichling and Bryant describe the practice of Belgrand in installing, upstream from the inverted siphons of the Paris sewers, detritus channels from 300 to 600 ft. in length, and of sufficient cross-section to reduce the mean velocity of flow to about 0.5 ft. per second.

Methods of Cleaning.— The cleaning of deposits from a fouled inverted siphon is usually effected by flushing, or, if necessary, by handwork with rods and scrapers. Various methods in use in ordinary sewer cleaning are applicable.

The theory of flushing is temporarily to increase the velocity through the pressure pipe enough to give it scouring force. The necessary volume is obtained either by holding back for a time the approaching sewage and suddenly releasing it, or by introducing flushing water from an outside source. In any case, an increased head on the siphon is called for, which in some instances may be possible only by the creation of back-water upstream. Methods in use for flushing comprise

(*a*) The temporary speeding up of pumps, if there is a pumping station on the sewer line.

Baldwin Latham describes the inverted siphons which convey crude sewage under the Mottlau and Keil-Graben channels at Dantzic to the pumping station as fitted with gates at the head so that, by temporarily holding back the flow and pumping out the sewage-well at the pumping station, and then starting up the pumps, a velocity as high as 9 ft. per second could be maintained for a time through the siphons. (Latham, 1878.)

It is stated by Mr. E. S. Dorr that when the Dorchester Bay inverted siphon of the Boston Main Drainage Works was built in 1883, a plan was contemplated for flushing it by passing through a ball of somewhat less than the 7 ft. 6 in. diameter of the tunnel, and that such a ball was actually made. There has been a reluctance, however, to introduce any such possible obstruction into the tunnel, and all cleaning has been accomplished by temporarily speeding up the velocity of flow. By measuring the loss of head between the ends of the siphon the hydraulic slope may be computed, and by employing the pumps as meters the volume of flow may be approximated. The value of C in the Chézy formula may thus be determined, an abnormally low value indicating foulness of the siphon, while progressively higher values reveal the success of efforts at flushing. In the early experiments values as low as about 80 were obtained before flushing, and as high as between 140 and 150 after flushing. Increased velocity for flushing is obtained by proper manipulation of the pumping units, admitting sea water to the pump wells if there is not enough sewage and storm water. At the entrance to the tunnel shaft provision was also made for suddenly tripping gates controlling the depth of flow in the approaching "deposit sewers," and thus admitting a powerful flush into the tunnel, but it has not been utilized. There is also provision at that point for by-passing the entire sewage flow around the shaft entrance and discharging it, in case of emergency, directly into Dorchester Bay. (Clarke, 1885.)

(*b*) Receiving the sewage flow at the head of the inverted siphon into flush tanks which automatically discharge when full. At Concord, Mass., at the head of two distinct 8-in. siphons crossing the Sudbury river are such flush tanks, one of 7 400 gallons and the other of 1 570 gallons capacity, discharging from 10 to 14 times a day. One of these is illustrated in *American Sewerage Practice*, Vol. I, p. 576.

(*c*) Providing a permanent flushing gate at the manhole at the head of the inverted siphon, or else grooves for the insertion of stop-planks when desired. This not only permits temporary storage of sewage in the approaching sewer, and the building up of an increased head for flushing, but allows isolating the

siphon for flushing from an exterior source, or for pumping out in case hand cleaning is necessary. Examples are found in the siphon of the Metropolitan main sewer at Portland and Main Streets, Cambridge, for which there is a flushing gate; and on four of the siphons at New Bedford, in which stop-planks may be inserted.

(*d*) Opening a blow-off at the low point of the pressure pipe of the inverted siphon. This is possible only in the exceptional cases in which there is a drainage channel low enough to receive the discharged water, but for a long pipe with large dip should give a powerful flush. It not only removes much accumulated deposit from the siphon, but empties the pipe for further cleaning without the necessity of pumping.

The 30-in. inverted siphon, 5 300 ft. long, on the sewer line from Fitchburg to the treatment plant, drops about 52 ft. from its upper end to its lowest point at the Nashua river, and is there provided with a 24-inch blow-off, discharging into the river.

The first inverted siphon at Gardner, built in 1890, is a 12-in. iron pipe, 1 050 ft. long, dropping about 25 ft. from the upper end to the low point, where a blow-off permits draining the siphon onto a small filter bed. A similar provision was made on the 12-in. siphon, 4 980 ft. long, built at Andover in 1898; this drops 66 ft. from upper end to low point, where the blow-off and small filter bed are located.

(*e*) Admitting clean water at the head of the inverted siphon from a permanent connection to a street water main, or through a hose line from a neighboring hydrant. The Andover siphon above referred to has a permanent connection to a 6-in. water main, and there are numerous other examples of this arrangement in the state. This method has also been provided for flushing the dry-weather pipe of the inverted siphons necessitated by subway construction in New York City, in cases where the pipe, though of minimum allowable diameter, nevertheless has at times too small a flow to prevent deposits. The inference seems fair that in the ordinary run of cases in this state flushing is effected with water from a hydrant. In a discussion by the Sanitary Section in October, 1904, it was stated by Mr. C. R. Felton that in the various inverted siphons in Brockton the velocity did not usually exceed 0.7 ft. per second, but could be increased by flushing to about 8 ft. per second.

(*f*) It is occasionally possible, in the case of an inverted siphon under a river, to introduce river water through a special connection to the chamber at the head of the siphon. This is done at Brockton, at the West Bartlett Street siphon.

Cleaning of inverted siphons by hand generally implies the use of jointed rods, with suitable scrapers or other tools at the end. The pipe to be cleaned must be emptied of water by draining at a blow-off, or pumping at a manhole; and during the cleaning operation the flow of sewage must be diverted through another pipe, if the siphon has more than one, or held back in the approaching sewer, or discharged through an overflow into a stream, if that be feasible. Such an overflow may serve the additional purpose of relieving the sewer of surplus water during storms, if the system be on the combined plan. The inverted siphons carrying combined sewers across under the subways of New York City usually comprise one small pipe for dry-weather flow, ranging from 8 to 42 ins. in diameter, and two much larger pipes for storm water. There is an incline at each end of the siphon, with a flat section between, under the subway floor. To facilitate cleaning of the dry-weather pipe, in case it becomes obstructed, the practice has been in recent years to provide a by-pass, of the same size as the dry-weather pipe, at each end of the siphon, controlled by sluice gates and leading into one of the storm-water pipes. By building temporary dams of sandbags in the dry-weather-flow channel at the ends of the siphon, the sewage can be diverted around the intervening pressure pipe, which is then available for emptying and cleaning.

The manhole or clean-out chamber at each end of a siphon gives access for rodding, for pumping, and, in the case of pipes of large size, for entrance. If the siphon is built with inclines at the ends, joined by a flat section, it is advantageous to have access also at the foot of the slopes, and in the later New York practice, above alluded to, an additional manhole leading to a clean-out chamber has been provided at those points. There the pipes have removable cast-iron covers, by which the interior may be opened up for pumping out the last of the water and for rodding.

At several of the New Bedford inverted siphons built in 1913, special provision is reported for the insertion of clean-out rods.

There is some objection to intermediate manholes on an inverted siphon if the sewage is free to rise in them, since grease

and other scum tends to fill up the shaft in time with a solid plug. Examples of this are found in the Dorchester Bay inverted siphon at Boston, and in a 36-in. inverted siphon under the Brandywine river at Wilmington, Delaware.

English treatises on sewerage have usually advocated installing in an inverted siphon a chain or a copper-wire rope, which might be worked back and forth, when necessary, to loosen deposits, supplementary flushing being used to sweep out the stirred-up material. The method does not appear to be used noticeably in this country, although a stoppage is reported to have been removed from the 10-in. Auburn Street siphon in Medford by dragging a rope through it.

With lapse of time it must happen with some inverted siphons carrying sewage that the interior will become more or less fouled, and as a result the effective cross-section diminished and the velocity and necessary working head increased. The tendency will be in such a case toward a condition of equilibrium, in which the velocity will have become sufficient to prevent further clogging, and evidence is occasionally noted that this has happened. In other instances a temporary increase in the volume of sewage, as, for example, following a rain, may cause a natural flushing action which will sweep out wholly or in part accumulated deposits. It may thus happen that a partially clogged inverted siphon will operate for years without causing serious trouble.

In a discussion by the Sanitary Section in October, 1904, (Bos. Soc. C. E., 1904), Mr. J. L. Woodfall cited evidence of an intermittent discharge of sludge from the Gardner siphon, built in 1890, which he attributed to the building up of head with increase of deposit, until a point was reached at which the mass was rapidly discharged. He also mentioned an instance in which stone dust from street macadamizing had been washed into the sewers through perforated manhole covers during stormy weather, and had settled in the siphon, but was suddenly flushed out to the extent of several cubic yards following an especially heavy rain.

In the discussion by the Sanitary Section, April 5, 1916, Mr. Otis F. Clapp described a 48-in. inverted siphon, 774 ft. long,

under the Providence River, at Providence. This has vertical shafts at the ends, with a sump, 5 ft. deep, at the upstream end. Repeatedly this sump has been found filled with deposit, but a subsequent slight rain would sweep it all out.

In the same discussion, Mr. L. M. Hastings spoke of the 24-in. inverted siphon under Lechmere Canal, in East Cambridge. This has a sump 5 ft. in diameter at the downstream end, which appears to remain constantly full of a muddy deposit, except for a passage through it, say a foot in diameter, which is kept sufficiently open by the flow of sewage, so that it has proved necessary to clean the siphon but once since it was built in 1894.

Further evidence on the point under consideration has been furnished by Mr. A. L. Shaw, Assistant Designing Engineer with Metcalf & Eddy, in the following communication to the Committee, dated August 30, 1920:

"While making a recent investigation along the Brandywine River in Wilmington, Delaware, the writer had occasion to note the operation of an inverted siphon, 36 in. in diameter, which crosses the river a short distance below the bleaching and finishing plant of the Joseph Bancroft & Sons Co. . . .

"The siphon is of reinforced concrete (built about 1908), and has at its upper end a series of chambers which imperfectly intercept grease and sediment, and from which the wastes (including a relatively small amount of sanitary sewage) pass over a brick wall, into a well or shaft about 9 ft. deep and about 3 ft. by 3.5 ft. in cross-section. A 30-in. concrete sewer leads into these chambers at the upper end, and from the bottom of the shaft at the lower end the 36-in. siphon leads off on a falling grade for about 220 ft. to its lowest point, at which there is a manhole, with cover above the normal hydraulic gradient. From this low point the siphon runs on a gradually ascending grade for about 200 ft. to a manhole, where it meets the grade of a 36-in. concrete gravity sewer. The maximum depth of the invert of the siphon below the ordinary water level in the central manhole is about 9 ft. The capacity of the 30-in. sewer above the siphon is about 16 mgd., and that of the 36-in. sewer below is about 24 mgd."

From suitable measurements, Mr. Shaw was able to compute the probable velocity of flow through the net opening in the siphon, which was believed to be considerably fouled by deposits.

That velocity ranged at three different observations from about 2.7 to 4.0 ft. per second.

"The apparent velocities in the reduced cross-section of the siphon are remarkably close to the velocities generally accepted as those necessary to maintain scouring (3 to 4 ft. per sec.). This suggests the probability that sedimentation had proceeded until the section was so reduced as to increase the velocity to the point where further deposits were prevented, establishing a state of equilibrium. This case perhaps illustrates why neglected siphons sometimes operate for years without giving serious trouble, deposits accumulating until the increased velocities automatically maintain a minimum opening. . . .

"The manhole at the low point of the siphon has proven a source of trouble. Grease and other floating matter are trapped in this manhole as they pass along under pressure in the siphon beneath. This results in the accumulation of a very putrid mass, which floats on the surface of the water near the top of the manhole and has been occasionally forced out and into the river at times of high discharge in the sewer, when the hydraulic gradient lies above the top of the manhole, due to the increased resistance of the partially choked siphon. Aside from this objectionable overflow, which of course could be overcome by raising the manhole, this instance emphasizes the undesirability of any interruption in the continuity of the bore of a siphon pipe, unless this is absolutely necessary in order to provide clean-out facilities."

Stoppages.— While as a rule the inverted siphons which have come to the Committee's attention appear to have given uninterrupted service, without undue expense for maintenance, there have been some exceptions in both these respects. Returns for this state give brief notes of serious stoppages in fourteen cases,— nine on separate systems, five on combined, and for diameters ranging from 6 to 24 ins. for each type. They are set forth in some detail elsewhere, but definite information as to the causes of stoppage was not furnished. In discussions it has appeared that not only grit and gravel, but masses of rags, cotton-waste, bent wire, tin cans, accumulations of grease, and other débris, even occasionally paving stones, have to be reckoned with as possibilities.

A remarkable, but highly instructive, instance of stoppage was that of the inverted siphon at Dean Street and Fourth

Avenue, Brooklyn, which was completed in July, 1911, and five years later became almost completely obstructed, giving the first and only important trouble experienced with inverted siphons built in connection with the New York subways. As described by Mr. J. L. Hunt, in a paper in *Municipal Engineers Journal* for 1917:

"The cleaning of this siphon proved to be an extraordinary and costly undertaking. The siphon consisted of two 48-in. pipes for the storm flow and one 18-in. pipe for the dry-weather flow, and replaced a portion of the 72-in. circular sewer in Dean Street. This sewer extends through Dean Street to Flatbush Avenue, where, fortunately, at the time, the subway excavation was in progress, which served as a reservoir for the back water. When the Sewer Department's cleaning force with their equipment arrived on the job there was a little flow passing through the siphon, but the water had risen to a considerable height in the manholes. They endeavored to rod the pipes and to free them by means of a water-jet, but owing to the depth of the sewage in the upstream chamber their efforts were futile. In the meantime, the situation was getting worse; water was backing up into the Pacific Street Station of the Fourth Avenue Subway through the toilet and ventilator drains, and threatened to stop the operation of the trains. Work on the Flatbush Avenue Subway in the vicinity of Dean Street had to be stopped on account of the depth of water in the cut, and a number of property-owners were complaining of the increasing depth of water in their cellars. The available pumps and men of the Sewer Department were inadequate for the task, and it was evident that immediate and unusual measures had to be adopted to combat the situation. In the emergency the subway contractor on the adjoining contract was called upon to assist in this work and was authorized to use every means at his disposal to speedily relieve the dangerous conditions. Accordingly, three or four large centrifugal pumps were set up in a short time at the different manholes in Dean Street and the sewage was temporarily pumped to the street surface, along which it flowed to a basin and manhole on another system. But although these pumps were more than sufficient to handle the dry-weather flow, they would occasionally get clogged with the heavy sewage, as the water was lowered, and it was not until a sand pump was procured and put in operation that it was possible to enter the upstream-siphon chamber to get at the seat of the trouble. This consumed about four days. . . .

"When it was possible to enter the siphon chamber it was found that the entrance to all three pipes was completely obstructed with a mound of débris consisting principally of a mattress, a load of lumber of various sizes, a long-handled shovel, a piece of blue-stone curbing, a wooden barrel, several iron pails, brick, pieces of concrete, tin cans, broom handles, umbrella frames, together with rags, wire, paper and other refuse. As soon as this rubbish was removed from the entrance to the pipes the sewage started to flow through them, and with the aid of a water-jet was soon flowing freely. The small pipe, however, had to be thoroughly cleaned.

"The most important conclusion to be drawn from the stoppage is that all inverted siphons should be regularly and carefully inspected and all obstructing materials removed from the chambers before a dam is formed by their accumulation. The dry-weather pipe should also be periodically cleaned. It is not likely that storm pipes as large as those at Dean Street will become clogged unless the small pipe is obstructed and left in that condition for a considerable period, but a regular inspection will reveal when this pipe is not properly carrying the flow, and it is a comparatively simple task to clean out this pipe by temporarily diverting the flow into the storm pipes. . . .

"This stoppage also shows that it is a wise precaution to construct an emergency overflow wherever possible, as low as conditions will permit, so as to provide an outlet when the siphon is obstructed. In connection with the Dean Street trouble, it was found that the chamber manholes were too small for pumping operations and at the same time to permit access with the necessary paraphernalia for cleaning. It also showed that it would be a good plan to construct clean-out manholes at the lower bends of the storm pipes as well as on the dry-weather pipe, to facilitate cleaning when necessary. Even though the storm pipes are big enough for a man to enter, it is hazardous work when all the cleaning has to be done from within the chambers. These clean-out manholes provide additional points of attack for cleaning, and the work is less dangerous and more rapidly accomplished."

Multiple Pipes.— While about three quarters of all the inverted siphons in Massachusetts for which returns were made have but a single pressure pipe, allusion has been made to the use of multiple pipes,— most often two in this state, nearly always three under New York City subways, and elsewhere even four, as under Wissahickon creek, Philadelphia. (Metcalf & Eddy, 1914.) In the separate system, additional siphon pipes

accommodate the increased volume of sewage that comes with lapse of time, without increasing the working head; at the same time, if provided with suitably arranged terminal chambers, any one pipe may be isolated temporarily for cleaning, and the sewage flow taken by the other pipes. In the combined system, because of the great variations in flow between dry-weather and storm conditions, the use of two or more pipes is especially advantageous, one being reserved for dry-weather flow, while storm flow spills over side walls or weirs in the entrance chambers at the head of the inverted siphon, into the special storm pipes. This arrangement has proved highly satisfactory on the combined system of Boston, and has been systematically used for the inverted siphons crossing under the New York subways. There the crest of the dam, or dams, at the upstream end of the siphon, has been put at about the computed height of the water surface for the full assumed dry-weather flow, after making due allowance for the probable loss of head in forcing that flow through the siphon. There is a similar dam, or dams, also at the downstream end of the siphon, so that in dry weather there is no chance at either end for foul sewage to enter a storm pipe. Where two or more storm pipes are installed, their entrances are usually at a common level, and likewise their exits. If desired, however, the entrances may be on different levels, and in that case the exits also, the pipes coming into play successively as the volume of rain-water increases. This plan was applied to the inverted siphon at Fourth Avenue and Butler Street, Brooklyn, but is thought not to offer advantages sufficient to commend it for general use.

Buoyancy. Ventilation.— An inverted siphon on the bed of a stream may have a dangerous buoyancy when empty, and care is therefore needed that it be sufficiently weighted to overcome any tendency to float.

English authorities on sewerage have in the past emphasized the importance of ventilating long inverted siphons, and especially the descending leg, asserting that otherwise the flow may be interfered with by accumulated air or gas. This difficulty does not appear to have been met in American practice, and no special provision for dealing with it has been brought to attention.

There have been some noteworthy instances, however, of disintegration of concrete in the vicinity of inverted siphons, which is thought to have been due to the evolution of hydrogen sulphide from especially stale domestic sewage, or from industrial liquids containing sulphur, the absorption of this gas by the condensed moisture on the exposed sewer walls, the subsequent formation of sulphuric acid, and its action in uniting with the lime of the cement to form sulphate of lime and thus to disintegrate the concrete.

The old Los Angeles outfall sewer, built in 1895, included two wood-stave inverted siphons, each about 3.4 miles long, joined by a section of brick-lined tunnel. The velocity through the siphons was very low, the time of passage long, and the condition favorable for putrefaction and the formation of foul gases. A strong odor was particularly noticeable at the outlet from the upper siphon and at a 12-ft. vertical drop in the sewer about a mile and a half downstream, and at these two points the disintegration was most severe, being confined to that part of the sewer above the ordinary water level. The damage became pronounced within a few years after the completion of the outfall, and was ascribed by Mr. Rudolph Hering, who investigated the case, to lack of ventilation. (Hardesty, 1906, and *Eng. News*, Nov. 8, 1900.)

There has been similar experience at the inverted siphons of the Metropolitan Sewerage Works of the Boston district, according to information received from Mr. F. D. Smith, Chief Engineer. The lines are long and the sewage is quite stale when it arrives in the lower reaches. The trouble is more serious, therefore, other things equal, as the outfall is approached. It was first observed at the Shirley Gut siphon, which is nearest the outlet of the North Metropolitan System. The upper manhole there was closed at a certain time and caulked tight, remained so for a year and a half, and was then opened up. The mortar of the brickwork on the approach side of the siphon was found soft, like putty, the brickwork between stop-plank grooves had peeled off in places, and some bricks in the roof arch of the sand-catcher had dropped out. There had been less action on the downstream side of the siphon. This siphon was the worst

on the Metropolitan System in the matter of disintegration. There was some at the Belle Isle Inlet siphon, but the ventilation was better there than at Shirley Gut. There was trouble also at the inverted siphon under the Aberjona river in Winchester, where the exposed surface sloughed off to a depth of perhaps half an inch.

Important Principles.— The extended and varied experience of the engineers of the New York City Public Service Commission in the designing and building of inverted siphons on combined sewers under difficult conditions should be of much value to other engineers, and the following essential principles as set forth in a paper by Mr. S. D. Bleich (Bleich, 1917), commend themselves to attention:

"1. Complete and effective separation of the house sewage and industrial waste from the storm run-off at all times.
2. Simplicity of construction.
3. As slight and easy changes in direction of flow as are practicable at the entrance and exit legs.
4. Easy curves where necessary.
5. Uniform section throughout entire length of siphon pipes.
6. Elimination of all features tending to obstruct flow.
7. Omission of all moving parts and mechanical devices.
8. Provision for easy access to all pipes without impairing any of the essential features.
9. Entrance and discharge openings to have sufficient area within the available height not to cause any back-water; and change of section or direction not to be too abrupt."

Respectfully submitted,

DWIGHT PORTER,
FRANK A. MARSTON,
HARRY E. HOLMES.

PLATE I
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS
SEPTEMBER, 1921
COMMITTEE ON INVERTED SIPHONS
FINAL REPORT

APPENDIX A. DATA RELATING TO INVERTED SIPHONS IN MASSACHUSETTS

Town	System	Location of Siphon	[illegible]	Year Built or Designed	Material of Pressure Pipe	Number of Pipes	Diameter	Length Feet	Drop Feet	Sewer Diameters and Slopes: Above Siphon	Sewer Diameters and Slopes: Below Siphon	Sump	Overflow or Blow-off	Special Provision for Cleaning Siphon	Frequency of Cleaning	Serious Stoppages	Authority for Data
Adams, North	Separate	State St	Hoosic River	1900	Cast-iron	Two	12	205	1.56			Upper end	None	4" water-pipe connection. Clean-outs at end manholes	Once in several years	None	W. J. Baucus, City Engr.
Amesbury	Separate		Powow River	1912	Cast-iron	One	16"	570	1.00	15"@0.1%	18"@0.0667%			6" water-pipe connection			J. L. Woodfall, Engr
Andover	Separate		Small brook	1912	Clay pipe	One	12"	338	3.00					Water-pipe connection			J. L. Woodfall, Engr
Andover	Separate	Line to filter beds	Valley	1898	Cast-iron	One	12"	4 980	12.5	15"@0.1%			Blow-off at low point	6" water-pipe connection			J. L. Woodfall, Engr.
Arlington	Separate	Mystic St	Mill Brook	1896	Cast-iron	Two	8"	38	0.4	15"@0.2%	15"@0.2%	Upper end	Overflow		Twice a year	Yes	G. E. Ahearn, Town Engr.
Athol	Separate	Exchange St	Canal	1894	Iron	Two (?)	6"	52 and 64					None		Once a year	None	
Attleborough	Separate	Hodges St		1912	Cast-iron	One	12"	155	0.58	20"@1/725	20"@1/725	None	None	6" water-pipe connection	Once a month	None	H. J. Goodale, Supt. Pub. Wks.
Attleborough, North	Separate	Main intercepter		1910	Cast-iron	One	10"	732	2.46	20"@1/1200	20"@1/100	None	Blow-off	None	None	None	F. A. Barbour, Engr
Attleborough, North	Separate	Force main		1910	Cast-iron	One	12"	2 028	1.25	22"@1/1500	To settling tank	None	Blow-off	None	None	None	F. A. Barbour, Engr
Boston	Combined	Old Harbor Point	Dorchester Bay	1879–83	Brick lined tunnel	One	90"	7 160							Irregular	None	"Main Drainage Works"
Boston	Combined	Calumet St., Roxbury	3 water mains	1890	Brick	One	33"	20	0.08			Both ends					
Boston	Combined	E. and W. First Sts., So. B.	Intercepter	1890	Iron	One	36"	8	3.20			None					
Boston	Combined	Huntington Ave	Muddy River conduit	1892	Cast-iron	Two	36" and 24"	30	0.3*	2' 6"x3' 0"	2' 6"x3' 3"	Both ends	None	None	Once a year	None	
Boston	Combined	E. and F. First Sts., So. B.	Intercepter	1893	Iron	One	36"	8	0.54			Upper end					
Boston		Brook crossing, Dorchester	Intercepter	1895	Brick	One	60"	8	0.20			None					
Boston		Brook crossing, Dorchester	Intercepter	1895	Brick	One	24"	8	0.33			None					
Boston	Combined	Brooks St., Dorchester	Tenean Brook Cond	1899	Brick	One	54"	55	0.02	4' 6"@1/2500	4' 6"@1/2500	At low point	18" gate overflow kept closed	None	None	None	
Boston	Combined	Wash. and Fairbanks Sts	Faneuil Val. Brook	1889	Iron	One	24"	12	0.17			None					
Boston	Combined	Pleasant St	Subway	1900	Iron	Two	30" and 16"	100	0.3			None					
Boston		High Level Intercepter	Oakland Brook Cond	1901	Brick	One	57"	34				None					
Boston		Crescent Ave. Brook Cond	30" gas pipe	1901	Brick	One	78"	42				None					Thomas F. Bowes, Engineer in Charge Sewer Service, and F. S. Dorr, Engr., Sewer Dept.
Boston		Faneuil Val. Brook Cond	30" sewer	1902	Brick	One	54"	57									
Boston	Surf. water	Francis St., Roxbury	30" water pipe	1903	Iron	One	12"	5				Upper end					
Boston		Mattapan Sq	78" conduit	1904	Concrete and brick	One	57"	42									
Boston		Dorch. High Level Sewer	Driveway	1906	Concrete, reinforced	One	48"	28									
Boston	Surf. water	Minot St., Dorchester	20" water pipe	1907	Brick	One	24"	8									
Boston	Combined	Ruggles St., Roxbury	Stony Brook Cond.	1908	Iron	Two	12" and 16"	20				None					
Boston	Combined	Tremont St	Stony Brook Cond	1908	Iron	Two	12" and 30"	33				None					
Boston		Lake St., Brighton	30" water pipe	1909	Concrete	One	54"	37	0.15								
Boston	Combined	E. and Anchor Sts., So. B.	30"x45" sewer	1912	Concrete, reinforced	One	Rect. 4'x5'	37	Level								
Boston		Saratoga St., E. Boston	Old Metr. Sewer	1912	Concrete, reinforced	One	Horseshoe, 5'x6'	78				None					
Boston	Combined	Maywan Ave., W. Rox.	Surface drain	1913	Cast-iron	One	36"	20				Lower end					
Boston	Combined	Washington St., W. Rox.	Metr. sewer	1914	Cast-iron	One	24"	28*	0.54	2' 12" and 2' 15"	24	None	None	None	Twice in 6 years	None	
Boston	Combined	Brighton	Faneuil Val. Brook Cond	1914	Cast-iron	One	48"	13				None					
Boston	Combined	Dorchester Ave., So. B.	N. Y., N. H. and H. R. R.	1915	Cast-iron	Two	48" and 24"	121				None					
Boston	Surf. water	Dorchester Ave	30"x36" sewer	1916	Concrete, reinforced	One	46"x88"	32									
Brockton	Separate	Cross St	Salisbury Plain Riv	1895	Iron	Two	12"	61 and 84	1.3	30"x45"@1/1500	30"x45"@1/1500	None	None	None	None	None	B. R. Chapman, City Engr
Brockton	Separate	Summer St		1893	Iron	Two	12"	49	1.1	30"x45"@1/1500	30"x45"@1/1500	None	None	None	None	None	B. R. Chapman, City Engr
Brockton	Separate	Forest St	Salisbury Plain Riv	1893	Cast-iron	Two	16" and 12"	79	1.56	30"x45"	32"x48"	None	15" overflow	None	None	None	B. R. Chapman, City Engr
Brockton	Separate	Pumping Sta		1895	Iron	Two	10" and 12"	60	1.5	20"	20"	None	12" overflow	None	Once a year	Yes	B. R. Chapman, City Engr
Brockton	Separate	W. Bartlett St		1895	Iron	Two	12" and 16"	36	2.6	22"x33"@1/800	22"x33"@1/800	None	12" overflow	12" river flush	Frequently	None	B. R. Chapman, City Engr
Brookfield, North	Separate			1893	Cast-iron	One	10"	1 580	3.75	12	8"	None	Blow off	Automatic tank. Blow-off	Twice a day	None	N. I. Craig, Spencer
Brookline	Combined	Washington St	Village Brook	1893	Cast-iron	One	12"	33	8.0	12	12	Both ends	8" blow-off	None	Once in 3 or 4 mos	Yes	F. A. Leavitt
Brookline	Combined	Walter and Morse Aves		1893	Cast-iron	One	12"	19		12	12	Both ends	8" blow-off	None	Once in 3 or 4 mos.	Yes	F. A. Leavitt
Cambridge	Separate	Massachusetts Ave		1897	Iron	One	8"	25		15	15	Upper end	None	None	None	None	L. M. Hastings, City Engr
Cambridge	Separate	Commercial St	Lechmere Canal	1895	Cast-iron	One	24"	132	0.63	24	24	Lower end	None	None	Once a week	None	L. M. Hastings, City Engr
Cambridge	Separate	Portland and Main Sts		1909	Cast-iron	One	42"	50		40"x44	40"x44	Upper end	None	None	4 times a year	None	L. M. Hastings, City Engr
Cambridge	Separate	Brookline and Douglass Sts		1908	Cast-iron	One	12"	90		12"	12"	Upper end	None	None	Twice a year	Yes	L. M. Hastings, City Engr
Cambridge	Combined	[illegible] and Plympton Sts.		1910	Concrete (24" C. I. [illegible])	Two	54"x54", and 24"	56	1.0	48"x54	48"x54	None	None	Plank dam, upper end	Occasionally	None	L. M. Hastings, City Engr
Cambridge	Separate	Huron Ave		1892	Cast-iron	One	10"	18	0.2	10"	15	Upper end	None	None	Seldom	Yes	L. M. Hastings, City Engr
Concord	Separate	Elm St		1899	Iron	One	8"	155	0.5	8"@0.0015	12"@0.0015	None	None	Storage tank and siphon	10 to 14 flushes per day	None	I. E. Robinson, Supt
Concord	Separate	Nashoba Road		1899	Iron	One	8"	125	0.5	8"	8"	Lower end	None	Storage tank and siphon	10 to 14 flushes per day	None	I. E. Robinson, Supt
Easthampton				1904		One	14"	736	Hyd. grade 0.003	12"	15'		Blow-off				J. L. Woodfall, Engr
Easton, North	Separate				Clay, encased in concrete	Three				39"			Overflow				H. P. Eddy, Consulting Engr.
Fitchburg	Combined	Line to treatment plant	Nashua River	1912	Cast-iron	One	30"	5 300*	Hyd. grade 0.0029	48"		Grit chamber	Overflow and blow-off	Gate at upper end	Several times each year	None	H. P. Eddy, Consulting Engr.
Gardner	Separate	Line to filter beds	Pond Brook valley	1890	Iron	One	12"	1 050	1.4	12"@1/100			8" blow-off		Once in several years	None	J. L. Woodfall, Engr
Gardner	Separate	Line to filter beds	Otter River valley	1900	Iron	One	16"	2 600	5.7	30"			None	6" water-pipe connection			J. L. Woodfall, Engr
Gardner	Separate			1904		One		776	3.0	15"@0.00255	18"@0.0010		Blow-off				J. L. Woodfall, Engr
Gardner	Separate			1904		One	16"	514	2.4	15"@0.00[illegible]5	15"@0.0015		Blow off				J. L. Woodfall, Engr
Greenfield	Combined		Green River	1910	Cast-iron	One	24"	127	0.1	30"@0.001	30"	Lower end	Overflow	8" water-pipe connection	Once in 6 mos.	Yes	Supt. Streets
Greenfield	Combined		Green River	1910	Cast-iron	One	6"	150	0.5	8"	8"	Lower end	Overflow		None	None	Supt. Streets
Greenfield	Combined		Green River	1910	Cast-iron	One	6"	106	0.5	8"	8"	Lower end	Overflow		Once in 6 mos.	Yes	Supt. Streets
Lawrence	Combined	Hampshire St	Spicket River	1885	Iron	One	8"	94	4.03	30	10"	Upper end	Both	None	3 or 4 times a month	Yes	A. D. Marble, City Engr
Longmeadow	Separate		Longmeadow Brook	1905	Cast-iron	One	8"	780	3.0			None	None	2" water-pipe connection	Twice a year	None	J. W. Hartigan, Supt
Longmeadow	Separate	Elmwood Ave	Valley	1917	Cast-iron	One	12"	302	3.01			None	6" blow-off	2" water-pipe connection	Twice a year	None	J. W. Hartigan, Supt
Longmeadow	Separate		Raspberry Br. valley	1913	Cast-iron	One	6"	1 385	17.25			None	6" blow-off	2" water-pipe connection	Twice a year	None	J. W. Hartigan, Supt
Longmeadow	Separate	Longmeadow St.	Lowland	1914	Cast-iron	One	6"	56	1.59			None	6" blow-off	2" water-pipe connection	Twice a year	None	J. W. Hartigan, Supt.
Malden	Separate	Bellvale St		1911	Cast-iron	One	8"	30	None	8"@1/150	8"@1/400	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Beach St		1910	Cast-iron	One	10"	40	None	10"@1/900	10"@1/900	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Lynn St		1909	Cast-iron	One	10"	32	None	10"@1/900	12"@1/900	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Maynard St		1911	Cast-iron	One	8"	25	None	8"@1/300	8"@1/400	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Springdale St		1910	Cast-iron	One	8"	25	None	8"@1/195	8"@1/400	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Main St., N. of Forest St		1899	Cast-iron	One	8"	20	None	8"@1/40	8"@1/40	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Claremont St		1910	Cast-iron	One	8"	25	None	8"@1/50	8"@1/100	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Malden	Separate	Pearl St	West End Brook	1893	Iron	One	15"	25	None	15"@1/600	15"@1/800	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr.
Malden	Separate	Russell St	West End Brook	1894	Iron	One	8"	24	None	8"	8"	Lower end	None	None	Once in a year or more	None	H. W. Esty, City Engr
Manchester	Separate	Beach St	Tidal creek	1914	Cast-iron	Two	6"	46	0.5			None	None		Flushed once in 3 mos	None	B. C. Allen, Engr
Medford	Separate	Auburn St		1907	Akron pipe	One	10"	157	1.0	10"	10"	None	Overflow	None	Flush weekly. Rods yearly	Yes	O. J. Whitney, Supt
Medford	Separate	Kilgore Ave		1910	Akron pipe	One	8"	12	None	8"	8"@0.0025	None	None	None	Flushed yearly	None	O. J. Whitney, Supt
Medford	Separate	Central Ave		1909	Akron pipe	One	10"	17	0.45	10"	10"	None	None	None	Flushed monthly	None	O. J. Whitney, Supt
Methuen	Separate	Ingalls St		1901	Iron	One	24"	104	0.22	24"@1/550	22"@1/466	Both ends	Blow-off	None	Twice a year	None	F. Stowers
Methuen	Separate	Broadway	Spicket River	1901	Iron	One	20"	90	0.15	20"@1/466	20"@1/466	Both ends	None	None	Twice a year	None	F. Stowers
Methuen	Separate	Private Land	Spicket River	1901	Iron	One	10"	188	0.34	10"@1/300	22"@1/466	None	None	None	Twice a year	None	F. Stowers
Milford	Separate	Depot St		1906	Cast iron	One	12"	1 781	3.91	18"@1/1200	24"@1/1600	None	Both	None	Only when necessary	None	F. A. Barbour, Engr
Milford	Separate	South Main St		1906	Cast iron	One	12"	920	1.90	24"@1/1600	24"@1/1600	None	Both	None	Only when necessary	None	F. A. Barbour, Engr
Milton	Separate	Adams St		1898	Iron	Two	6"	52	0.5	8"	8"	Both ends	Overflow	Water-main connection	Flushed monthly	Yes	F. Kemp, Supt
New Bedford	Combined	South St		1913	Akron pipe	One	12"	32	0.12	12"	12"	None	None	Clean out for rods			S. G. Proverbs
New Bedford	Combined	David St.		1913	Akron pipe	One	12"	16	0.10	10"@0.0461	12"@0.0075	None	Overflow	Clean-out for rods			S. G. Proverbs
New Bedford	Combined	Middle and Water Sts		1915	Akron pipe	One	18"	43	0.5	30"	30"	None	Overflow	Provision for stop-planks			S. G. Proverbs
New Bedford	Combined	Willis St. and Acushnet		1915	Akron pipe	Two	30" and 24"	39		42"	48"	None	None	Provision for stop-planks			S. G. Proverbs
New Bedford	Combined	Potomska St		1913	Concrete reinforced	One	30"	32	1.2	30"	30"	None	None	Stop planks. Clean-out			S. G. Proverbs
New Bedford	Combined	Maxfield and Second Sts		1915	Akron pipe	One	30"	32		30"	30"	None	None	Provision for stop-planks			S. G. Proverbs
Newton	Separate	Chestnut St		1896	Iron	One	6"	108	0.54	8"	8"	Both ends	None	None	Once a year	None	E. H. Rogers, City Engr
Newton	Separate	Greenwood Ave	B. and A. R. R.	1896	Iron	One	6"	100	0.50	8"	8"	Both ends	None	None	Once a year	None	E. H. Rogers, City Engr
Newton	Separate	Hemlock Gorge		1902	Iron	Two	8" and 6"	245	6.77	20"x30"	20"x30"	Lower end	Overflow	None	Once a year	None	E. H. Rogers, City Engr
Newton	Separate	W. Newton depot		1897	Iron	One	6"	120	0.60	8"	8"	Both ends	None	None	Once a year	None	E. H. Rogers, City Engr
Newton	Separate	Watertown St. at Albemarle		1897	Cast-iron	One	8"	62	5.37	18"@0.005	24"x36"@0.001	None	None	None	Yearly or oftener	None	E. H. Rogers, City Engr
Newton	Surface drain	Elmwood Park	B. and A. R. R.	1896	Cast-iron	One	60"	94	0.94	66"	72"	Upper end	None	None	Yearly or oftener	None	E. H. Rogers, City Engr
Norwood	Separate	Line to filter beds		1907	Cast-iron	One	16"	3 876	4.7	20"@0.0016	24"@0.0008	None	Blow-off	16" stop-gate			L. D. Thorpe, Engr
Peabody	Separate	Grove St		1906	Cast-iron	One	20"	52	0.13	20"@0.0025	20"@0.0025	None	Overflow	None	Twice a year	None	E. A. Emerson, Town Engr
Peabody	Separate	Colley St		1907	Cast-iron	One	8"	65	0.85	6"@0.045	15"@0.001	None	None	None	Twice a year	None	E. A. Emerson, Town Engr.
Pittsfield	Separate	Fern St	Housatonic River	1903	Cast iron	One	12"	120	0.8	12"@0.002	24"x36"@0.001	Lower end	Overflow	None	10 days or 2 weeks	None	H. I. Strong
Pittsfield	Separate	Wahconah St		1893	Cast-iron	One	18"	130	0.4	18"@0.002	18"@0.002	Lower end	Overflow	None	Once in 3 mos.	None	H. I. Strong
Quincy	Separate	Copeland and Common Sts	Water main	1897	Clay	One	8"	20	0.2			None	None	Water-main connection	Monthly	None	W. T. McKenzie
Salem	Separate	Grove St. trunk sewer	North River	1906	Iron	Two	36"	58	0.5	52"	52"	Both ends	None	None	Once a year	None	G. F. Ashton, City Engr
Salem	Separate	North St	North River	1906	Cast-iron	Two	20"	61		24"	24"	Both ends	None	None	Once a year	None	G. F. Ashton, City Engr
Salem	Separate	Canal St		1909	Iron	Two	24"	31	1.9	36"@1/2500	36"@1/2500	Both ends	None	None	Once a year	None	G. F. Ashton, City Engr
Salem	Separate	Mill St		1910	Cast-iron	Two	20"	60	0.3	24"@1/1200	24"@1/1200	Both ends	None	None	Once a year	None	G. F. Ashton, City Engr
Salem	Separate	Lafayette St		1909	Iron	Two	36"	35	0.3	48"@1/2500	48"@1/2500	Both ends	None	None	Once a year	None	G. F. Ashton, City Engr
Somerville	Combined	School St	B. and M. R. R.	1889	Iron	One	16"	105	1.6	12"@0.0060	12"@0.0151	None	6" overflow	None	Once a year	None	E. W. Bailey, City Engr
Somerville	Combined	Berwick St	B. and M. R. R.	1886	Cast-iron	Two	8" and 12"	89	0.2	12"@0.0013	12"@0.0024	None	8" overflow	None	Once a year	None	E. W. Bailey, City Engr
Southbridge	Separate	Mechanics St		1908	Cast-iron	One	8"	95		10"@1/1000	10"@1/1000	None	None	None			W. S. Johnson, Engr
Spencer	Separate	Lower Main		1897	Cast-iron	One	12"	3 127	16.8	18"	15"@0.003	None	2 blow offs	Blow-offs and 2" water-pipe connection	Once in 3 mos	None	N. I. Craig, Engr
Taunton	Separate	W. Britannia St		1902	Cast-iron	Two	6" and 4"	73	0.3	8"@0.0035	10"@0.003	None	None	Water-main connection	Monthly	None	A. K. Crowell, City Engr
Waltham	Separate	Calvary St	Brook	1892	Iron	One	24"	22	None	34"x51"@0.0012	34"x51"@0.0016	Lower end	None	None	Once a year	None	B. Brewer, City Engr
Waltham	Separate	School St		1912	Akron pipe	One	8"	14	0.06	8"@0.004	8"@0.004	Lower end	None	None	Once a year	None	B. Brewer, City Engr
Waltham	Separate	Newton St	Charles River	1892	Iron	One	24"	128	0.85	32"x48"@0.001	32"x48"@0.001	Lower end	Overflow	Ejector	Once a year	None	B. Brewer, City Engr
Waltham	Separate	Wood Ave	Cram's Cove	1897	Iron	One	8"	107	0.43	10"@0.002	10"@0.002	Lower end	Overflow	None	Once a year	None	B. Brewer, City Engr
Watertown	Separate	Nichols and Dexter Aves		1896	Clay pipe	One	12"	12	0.03	12"	12"	Both ends	None	None	When necessary	None	W. F. Learned, Town Engr
Watertown	Separate	Arlington St.	62" water pipe	1908	Clay pipe	Two	10" and 15"	38	0.05	18"	18"	None	None	Gates	None	Once	W. F. Learned, Town Engr
Watertown	Separate	Church St		1896	Clay pipe	One	6"	11	None	6"@1/100	6"@1/100	None	None	None		None	W. F. Learned, Town Engr
Watertown	Separate	Main St. at Church St		1896	Clay pipe	One	6"	11	0.11	6"	6"	None	None	None		None	W. F. Learned, Town Engr
Watertown	Separate	Arsenal connection	Charles River	1897	Cast-iron	One	12"	250	0.24	18"	18"	Both ends	None	None	None	None	W. F. Learned, Town Engr
Watertown	Separate	Grayken St	Charles River	1896	Cast-iron	One	24"	290	None	24"@1/1000	24"@1/1000	Lower end	24" blow off	None	Once a year	Twice in 1 yr	W. F. Learned, Town Engr
Winchester	Separate	Cedar St		1895	Clay pipe	Two	10"	112	0.44	15"@1/500	15"@1/500	Lower end	Overflow	None	Rods once a year. Flush 6 times a year	None	J. Hinds, Town Engr
Winchester	Separate	Cross St	Willow Brook	1896	Akron pipe	Two	10"	55	0.44	12"	12"	Lower end	None	None	None	None	J. Hinds, Town Engr
Winchester	Separate	Parkway to Everett Ave		1894	Cast-iron	One	16"	130	0.2	18"@0.0016	18"@0.0016	Lower end	Overflow	None	Rods once a year. Flush 6 times a year	None	J. Hinds, Town Engr
Winchester	Separate	Walnut St. outfall		1894	Iron	One	12"	15	0.4	12"	12"	None	Overflow	None	Rods once a year. Flush once in 2 weeks	None	J. Hinds, Town Engr
Woburn	Separate	Eastern Ave		1895	Akron pipe	One	8"	18	0.1	8"@1/200	8"@1/200	None	None	None	Twice a year	None	W. H. Jones, City Engr.
Worcester	Separate	Mill St		1893	Cast-iron	One	16"	42	4.84	15" oval	18"x27"@1/500	Lower end	None	None	Two or three times a year	None	M. Gault, Supt. Sewers
Worcester	Separate	Main St	Fitnuck Brook	1894	Cast-iron	One	24"	52	0.29	16"x24"@1/300	16"x24"@1/300	Lower end	None	None	Two or three times a year	None	M. Gault, Supt. Sewers
Worcester	Separate	Southbridge St		1894	Cast iron	One	24"	126	0.29	18"x27"@1/500	18"x27"@1/500	Lower end	Overflow	None	Two or three times a year	Yes	M. Gault, Supt. Sewers
Worcester	Separate	Park Ave		1896	Cast iron	Two (plugged)	10"	36	0.06	15" oval@1/400	15" oval@1/400	Lower end	None	None	Two or three times a year	None	M. Gault, Supt. Sewers
Worcester	Separate	Webster St		1893	Brick and [illegible]	Two	20"x30", and 24	108 and 188		20"x30"@1/750	20"x30"@1/750	Lower end	None	None	None	None	M. Gault, Supt. Sewers
Worcester		Millbury St			Iron	One	16"	40						Miller siphon tank			M. Gault, Supt. Sewers
Worcester	Intercepter in Combined System	Quinsigamond Ave	Millbrook Cond	1898	Cast-iron	Three	30"	50				Chambers at each end	None	Gates at each end			H. P. Eddy, Consulting Engr
Worcester	Intercepter in Combined System	Quinsigamond Ave	Millbrook Cond	1898	Cast-iron	Three	30"	206					None	Gates at each end			H. P. Eddy, Consulting Engr

METROPOLITAN MAIN LINES

Town	System	Location of Siphon	[illegible]	Year Built or Designed	Material of Pressure Pipe	Number of Pipes	Diameter	Length Feet	Drop Feet	Sewer Diameters and Slopes: Above Siphon	Sewer Diameters and Slopes: Below Siphon	Sump	Overflow or Blow-off	Special Provision for Cleaning Siphon	Frequency of Cleaning	Serious Stoppages	Authority for Data
Winchester	Combined		Aberjona River	1894	Akron pipe, concrete reinf.	One	24"	55	0.45	33"x37"@1/2350	33"x37"@1/2250	None	None	None	None	None	Met. Water and Sew. Bd.
West Medford	Combined		Mystic River	1894	Akron pipe, concrete reinf.	One	24"	90	1.6	36"x43"@1/1500	36"x43"@1/1500	Upper end	Overflow	None	None	None	Met. Water and Sew. Bd.
Winthrop	Combined		Shirley Gut	1894	Brick in iron [illegible]	One	73.5"	253	1.27	109"@1/3200	109"@1/3200	Upper end	None	None	None	None	Met. Water and Sew. Bd.
Winthrop	Combined		Belle Isle Inlet	1895	Concrete	Three	57"	230	1.43	102"x110.5"@1/3000	102"x110.5"@1/3200	Upper end	Overflow	None	None	None	Met. Water and Sew. Bd.
East Boston	Combined		Chelsea Creek	1895	Brick	One	67.5"	515	5.17	100"x110"@1/3000	Pumping Sta.	Upper end	Overflow	None			Met. Water and Sew. Bd.
Everett	Combined		Malden River	1895	Concrete	One	42"	275	1.13	56"x61"@1/1100	56"x61"@1/1400	Upper end	Overflow	None	None	None	Met. Water and Sew. Bd.
Charlestown	Combined		Mystic River	1895	Brick	One	57.5"	1 085		78"x86"@1/3000	Pumping Sta.	None	None	None	None	None	Met. Water and Sew. Bd.
Arlington	Separate	Lake St. Branch		1909	Akron pipe, concrete reinf.	Two	6" and 10"	50	0.44	Local sewer	27"x33"@1/1500	Upper end	Overflow	None	None	None	Met. Water and Sew. Bd.

[redacted]

APPENDIX B.

Analysis of Data Received Relating to Inverted Siphons in Massachusetts.

Massachusetts cities and towns having sewerage systems number 110, to all of which application was made for information, and from 45 of which data have been received regarding one or more inverted siphons. About two thirds of all the 145 individual siphons reported are on the domestic sewers, or the separate system; about one quarter on combined sewers or surface-water conduits; eight on Metropolitan main lines; and the remaining few were not specified as to type.

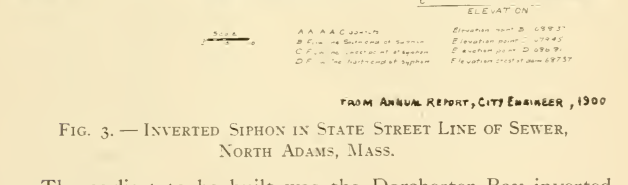


Fig. 3. — Inverted Siphon in State Street Line of Sewer, North Adams, Mass.

The earliest to be built was the Dorchester Bay inverted siphon of the Boston Main Drainage Works, which was completed in 1883, followed by an 8-in. line under the Spicket river, on Hampshire Street, Lawrence, in 1885; but one third of the whole number belong to the five-year period, 1893-1897.

The nature of the obstacle which led to the use of an inverted siphon in individual cases was not generally stated, but for a total of about forty siphons was given as brook, river, or tidal water; other sewers, surface water conduits, water mains, and railroad lines accounting for from five to ten examples each; with a few scattering ones otherwise explained.

Cast iron has been used for the pressure pipe of the inverted siphon in more than two thirds of all the cases reported. For

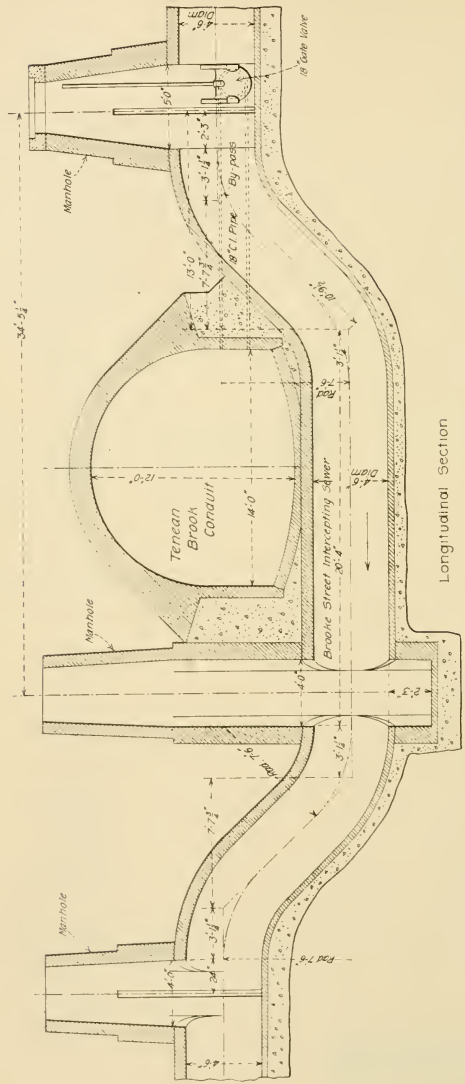


FIG. 4. — BROOKE ST. INTERCEPTING SEWER SIPHON UNDER TENEAN BROOK CONDUIT, BOSTON, MASS.

some twenty siphons clay sewer pipe has been used, in a few cases reinforced with concrete, as in the Metropolitan main line under the Aberjona river, in Winchester. Concrete has been employed in nearly a dozen cases, about equally divided between plain and reinforced; and approximately a dozen siphons of brickwork, under light pressure, were reported for Boston.

Of those inverted siphons which were described as installed on the separate system, three quarters consist of but a single pressure pipe each. All those in Brockton and all in Salem,— five in each city, — have two pipes; and examples are also found in a dozen other towns. In a single case, on the trunk-line siphon in North Easton, there are three pipes.

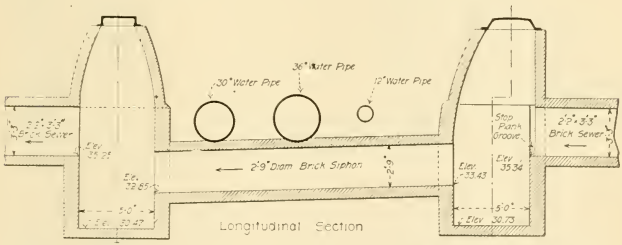


Fig. 5. — Brick Siphon in Calumet Street Sewer, Boston, Mass.

With inverted siphons on combined sewers the proportions are but little different from the above. Most have but one pipe; five installations with two pipes were reported for Boston, and examples are also found in Cambridge, New Bedford and Somerville. At Belle Isle Inlet, on the North Metropolitan main line, there is a three-pipe siphon, also two on the intercepters at Worcester.

Outside of the Metropolitan main sewers, and the line under Dorchester Bay of the Boston Main Drainage System, the various inverted siphons reported upon, including both separate and combined systems, range in length from 5 ft. to about 5 300 ft., and in diameter from 4 in. (one case) to 78 in. (one case). At least a dozen of these, namely, at Andover, Easthampton, Fitchburg, Gardner, Milford, North Attleboro, North

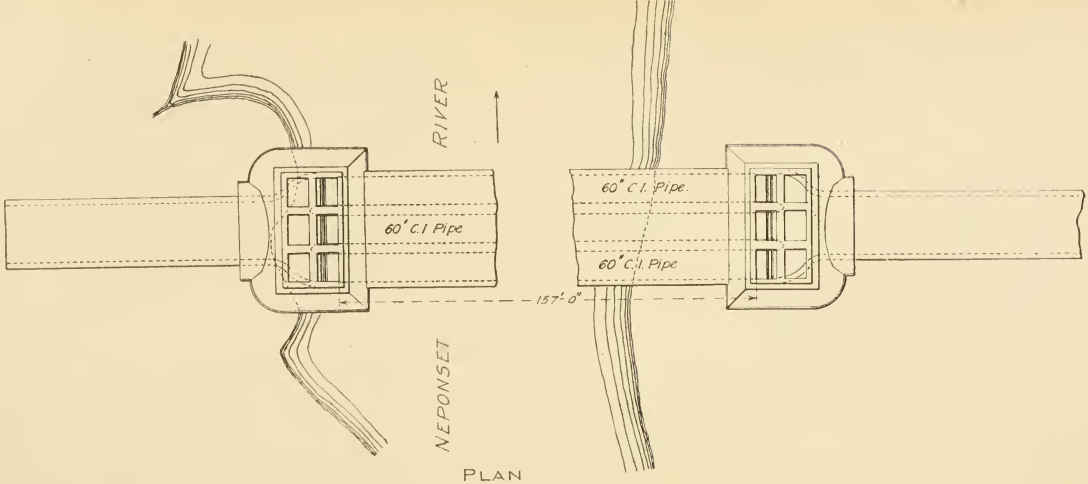


FIG. 6. — NEPONSET RIVER SIPHON IN HIGH LEVEL SEWER, MASS. METROPOLITAN SEWERAGE WORKS.

Brookfield, Norwood and Spencer, ranging from about 500 to about 5 300 ft. in length, were built as a means of reaching certain treatment plants, usually sand filters.

The 4-in. pipe just referred to is used in parallel with a 6-in. in the inverted siphon in West Britannia Street, Taunton. There are nine examples in which single 6-in. pipes are used, in one case up to a length of 1 385 ft., and six others in which they are used in parallel with a 4-, 6-, 8-, or 10-in. For practical reasons the minimum diameter to be considered advisable for inverted siphons is likely to be placed at about the same figure as for sewers in general, say 6 in. or 8 in. on separate systems, and 10 in. or 12 in. on combined. The 4-in. and all but two of the 6-in. siphons above referred to are on separate systems, and all are reported to have been free from serious stoppage, except a pair of 6-in. pipes on Adams Street, Milton, and a 6-in. line at Greenfield. On combined systems the only cases for which a smaller diameter than 12 in. was returned were the old Hampshire Street siphon in Lawrence, built in 1885, 8 ins. in diameter, reported to have been frequently clogged; a combination of 8-in. and 12-in. in parallel, on Berwick Street, Somerville, installed in 1886, and stated to have been free from stoppages, and two 6-in. siphons in Greenfield.

Certain questions on the Committee's blanks were aimed at bringing out the head provided in design for the individual inverted siphons, but were so interpreted in answering as not to prove very helpful. The available head is approximately the difference in levels of the invert of the main sewer on reaching and on leaving the siphon. As thus defined, its value appears in a number of returns to be not more than 0.1 ft., which is barely sufficient to provide velocity head alone for a velocity of 2.5 ft. per second. These cases are of rather short siphons, not over 60 ft. long, and nearly all on separate systems, but it seems probable that the actual head required is produced by a back-water rise of level in the approaching sewer. The head to be provided tends to increase with the length of the siphon, owing to the greater friction loss, and the highest value reported is 17.25 ft., for the 6-in. siphon under Raspberry Brook valley, Longmeadow, 1 385 ft. long.

Overflows are provided on about 30 of the inverted siphons, presumably discharging in most cases into the streams under which the siphons pass. They have the manifest value on a combined system of being able to relieve the siphon of a surplus of storm water; and on any single-pipe siphon, of allowing it to be temporarily cut off for cleaning, without requiring sewage to be stored upstream in the pipe system.

Blow-offs for emptying the inverted siphon during cleaning operations are reported in 18 cases.

Much diversity of practice appears in the matter of providing sumps at inverted siphons. For 16 siphons sumps are reported at the upper end, for 32 at the lower end, for 17 at both ends, and for 58 at neither end.

In the great majority of inverted siphons in this state no special provision for flushing has been installed. In several cases, however, flushing gates have been provided at the head of the siphon, and in five others reliance is placed on the use of stop-planks; at the head of 15 siphons connections of from 2 ins. to 6 ins. diameter have been made to water mains; at Concord and North Brookfield are examples of the use of storage tanks automatically discharged by true siphons, and at the West Bartlett Street inverted siphon in Brockton there is a 12-in. connection for flushing with river water. On three of the New Bedford siphons there is a special clean-out connection for the insertion of rods when needed.

In the matter of maintenance it is to be noticed that flushing is the principal reliance for keeping the inverted siphons clear. On 54 out of 83 siphons in Massachusetts for which we have returns on this point, flushing is used, being supplemented on 32 of them by cleaning with tools, usually at less frequent intervals, while in 11 cases tools are said to be the only method employed. In about one third of those cases in which flushing is resorted to, it is applied once a year, in an equal number of others at intervals of from two to six months, in half as many others at intervals of from one week to four weeks, and in two instances, in Concord, sewage is stored and automatically discharged into inverted siphons at intervals of between two and

three hours. From these figures it is evident that many of the siphons are flushed more frequently than the main sewer systems.

As to the cost of cleaning inverted siphons very little definite information was elicited. In most cases it was stated that data were not available. In ten the cost was said to be nothing, or very slight, but for 15 siphons figures were given. The highest was $350 for the Huntington Avenue siphon under Muddy River, Boston — Brookline; and the next highest was $285, for the Gaylen Street siphon under the Charles River in Watertown, a 24-in. pipe, 290 ft. long, flushed once a year and cleaned twice a year by other means. The cost given for the Adams Street siphon, in Milton, was $160; this has two 6-in. pipes, 52.5 ft. long, and is flushed once a month and cleaned by other means two or three times a year. In the dozen other cases reported the cost ranged from $1 to $45.

None of the siphons reported upon in this state has ever had to be dug up on account of stoppage, but fourteen have been seriously clogged, as follows:

1. Mystic Street siphon under Mill brook, Arlington; two 8-in. pipes, 38 ft. long, separate system. Cleaned by diverting sewage through overflow to stream and pumping water from clean-out chambers.

2. Siphon at pumping station, Brockton; two pipes, 10-in. and 12-in., 60 ft. long, separate system. Cleaned with rods.

3. Washington Street siphon at Village brook, Brookline; single 12-in. line, 33 ft. long, combined sewer. Partly stopped, but cleaned by by-passing sewage and scraping out deposit.

4. Walter Ave. siphon at Morse Ave., Brookline; single 12-in. line, 19 ft. long, combined sewer. Partly stopped, but cleaned by by-passing sewage and scraping out deposit.

5. Brookline Street siphon at Douglas Street, Cambridge; single 12-in. line, 90 ft. long, separate system. Stopped once, but cleaned with rods.

6. Huron Avenue siphon, Cambridge; single 10-in. line, 18 ft. long, separate system. Cleaned by scraping.

7. Line under Green river, at Greenfield; single 6-in. pipe, 106 ft. long, combined sewer. Lower manhole filled with deposit and flow stopped.

8. Line under Green river, at Greenfield; single 24-in. pipe, 127 ft. long, combined sewer Lower manhole filled with deposit and flow stopped.

9. Hampshire Street siphon under Spicket river, Lawrence; single 8-in. pipe, 94 ft. long, combined sewer. Said to be frequently stopped. Cleaned by diverting sewage through overflow to river, scraping out siphon pipe and flushing with hose stream from hydrant.

10. Auburn Street siphon, Medford; single 10-in. line, 157 ft. long, separate system. Cleaned by dragging rope through pipe.

11. Adams Street siphon, Milton; double line of 6-in. pipe, 52 ft. long, separate system. Pumped out, and presumably cleaned with rods.

12. Arlington Street siphon, Watertown; two pipes, 10-in. and 15-in., 38 ft. long, separate system. Stopped once, soon after construction, from mason having left some of his staging in manhole.

13. Gaylen Street siphon under Charles river, Watertown; single 24-in. line, 290 ft. long, separate system. Stopped twice in one year, pumped out, and cleaned by further means which were not stated.

14. Southbridge Street siphon, Worcester; single 24-in. line, 126 ft. long, separate system. Cleaned by scraping.

APPENDIX C.

Detailed Descriptions of Certain Inverted Siphons in Massachusetts.

Amesbury, Mass. (Boston Soc. C. E., 1916, J. L. Woodfall.) Built under Powow river. Separate system. Siphon built in 1912. Length, 570 ft. Iron. One line. 16-in. Low point, 12.5 ft. below inlet and 11.5 ft. below outlet. Inlet sewer, 15-in., grade, 1/1 000; outlet sewer, 18-in., grade, 1/1 600. Siphon considered good for 2.5 ft. per second velocity and 1 700 gals. per minute discharge. Provided with 6-in. water-pipe connection for flushing.

A second siphon at Amesbury passes under a small brook. Built in 1912. Length, 338 ft. Vitrified pipe. One line. 12-in. Inlet and outlet sewers also 12-in. Low point, 7 ft. below inlet and 4 ft. below outlet. Siphon considered good for 5.5 ft. per second velocity, and about 1 900 gals. per minute discharge. Provided with connection to water main at manhole for flushing.

Andover, Mass. (Boston Soc. C. E., 1904 and 1916, J. L. Woodfall.) Built under a valley to reach filter beds. Separate system. Siphon built in 1898. Length, 4 980 ft. Iron. One line. 12-in. Low point 66 ft. below inlet and 53.5 ft. below outlet, latter at settling tank. Siphon considered good for velocity of about 2.5 ft. per second, and discharge of about 900 gals. per minute. Flushing provided for by connection with 6-in. water main. Blow-off gate at low point, discharging upon small filter bed. In 1904, Mr. Woodfall stated that measurements by the State Board of Health showed an average daily flow of about 125 000 gals. and a velocity in the siphon of 0.25 ft. per second. Up to that time no trouble had been experienced with the siphon; it had been flushed but once from the water main, and the blow-off gate had not been opened at all for flushing.

Easthampton, Mass. (Boston Soc. C. E., 1916, J. L. Woodfall.) Built in highway, in 1904. Separate system.

Length, 736 ft. Iron. One line. 14-in. Inlet sewer, 12-in. on 0.0018 grade; outlet sewer, 15-in. on 0.0015 grade. Hydraulic gradient for siphon 0.003. Siphon considered good for 2 ft. per second velocity, and about 1 050 gals. per minute discharge. Has blow-off gate at low point.

Gardner, Mass. (Boston Soc. C. E., 1904, J. L. Woodfall.) From Conant Street, under valley of Pond brook, to filtration area. Separate system. Siphon built in 1890. Length, 1 050 ft. Iron. One line. 12-in. Lowest point, 25.4 ft. below upstream sewer and 24 ft. below outlet. Slope of hydraulic gradient, 0.00133. Manhole at upper end. No sump. Terminates in settling tank. Crosses Pond brook in covered box supported on short bridge. 8-in. blow-off branch at lowest point, near brook, discharging onto small filter bed. Siphon built with leaded joints, under 4 to 4.5 ft. cover, changes in direction and grade with straight pipe. Put in operation in spring of 1891. Blow-off opened several times in summer of 1891, again in summer of 1896, again about 1901, but not otherwise previous to 1904. Considerable sludge discharged each time blow-off gate was opened. Substantial amount of rags and other solids discharged into settling tank every day. Evidence of intermittent clogging of siphon at times, and self-clearing under resulting increased head. Measurements indicated average velocity in siphon of about 0.4 ft. per second, in 1904. Siphon not flushed from July, 1898, until February, 1899.

	Discharge.	Loss of Head.
Before flushing	398 000 gallons per day	0.886 ft.
Before flushing	422 000 gallons per day	0.940 ft.
After flushing	255 000 gallons per day	0.230 ft.
After flushing	412 000 gallons per day	0.509 ft.
Computed for clean water	255 000 gallons per day	0.102 ft.
Computed for clean water	412 000 gallons per day	0.263 ft.

In discussion by Sanitary Section, Boston Soc. Civ. Engrs., April 5, 1916, Mr. Woodfall gave maximum working capacity of siphon under normal conditions at about 700 gals. per minute, and corresponding velocity about 2.5 ft. per second.

Gardner, Mass. (Boston Soc. C. E., 1904 and 1916, J. L. Woodfall.) Inverted siphon under valley of Otter river to fil-

tration area. Separate system. Siphon built in 1900. Length, 2 600 ft. Iron. One line. 16-in. Lowest point, 38.2 ft. below upstream sewer and 32.5 ft. below outlet. Slope of hydraulic gradient, 0.0022. For purpose of storage, last 427 ft. of 12-in. upstream sewer built of 30-in. vitrified pipe. From this pipe the flow may be sent through a dosing chamber containing two 18-in. Miller siphons, to the inverted siphon, or may be by-passed direct if desired. The dosing tank was installed to give intermittent flow to the filter beds, but is not now so used, though available for flushing the inverted siphon. Main reliance for flushing is placed in a connection at the head of the inverted siphon to a 6-in. water main under 350 ft. head. In using this connection a 16-in. gate just upstream on the inverted siphon is first closed. There is no blow-off on the line. The discharge goes to a settling tank and thence to sand filters. In 1904 the average daily flow, as measured by the State Board of Health, was 250 000 gals. Mr. Woodfall considered the siphon good for about 1 900 cu. ft. per minute and a velocity of 3 ft. per second.

Gardner, Mass. (Boston Soc. C. E., 1916, J. L. Woodfall.) On South Gardner outlet, on line with old and new filter beds. Separate system. Siphon built in 1904. Length, 776 ft. Iron. One line. 16-in. Inlet sewer, 15 in.; outlet sewer, 18-in. Lowest point of siphon, 11.2 ft. below inlet, and 8.2 ft. below outlet. No special provision for flushing, but blow-off gate provided at low point. Siphon considered good for a velocity of about 4 ft. per second, and discharge of 2 600 gals. per minute.

Another inverted siphon built on same line in same year. Length, 514 ft. Iron. One line. 16-in. Inlet and outlet sewers, 15-in. Low point of siphon, 6.7 ft. below inlet and 4.3 ft. below outlet. No special provision for flushing, but blow-off gate provided at low point. Siphon considered good for a velocity of about 4.5 ft. per second, and discharge of 2 900 gals. per minute.

Fitchburg, Mass. (Boston Soc. C. E., 1916, and the Semi-Annual Report of Sewage Disposal Commission, Dec. 31, 1912. H. P. Eddy, Cons. Engr., David A. Hartwell, Chief Engineer.) Passes from siphon chamber at lower end of 48-in. intercepting

sewer, down the valley of the Nashua river, across under the river to high land taken for the treatment works. Built in 1912. Combined system. Length of siphon from siphon chamber, about 5 300 ft. Cast iron. One line. 30-in. Hydraulic gradient for siphon, 0.0029. Invert at lowest point, 51.9 ft. below invert of 30-in. pipe at siphon chamber. Discharging capacity placed at 13 250 000 gals. per 24 hours. Grit chamber about 1 400 ft. above siphon chamber. A 36-in. connection provided at siphon chamber for additional siphon pipe to be added in the future when necessary. Overflow at siphon chamber for excess storm water during considerable rains, with 24-in. pipe line to spill it into river. Gate, with 24-in. blow-off pipe to Nashua river, at lowest point of siphon. One year after the siphon was put into service it was opened and examined throughout its length. The only accumulation found was about six cu. yds. of sand at a point where there is a sharp turn in the pipe. The average flow in the intercepting sewer in 1910 was only about 4 000 000 gals. per day, equivalent to a velocity of about 1.25 ft. per second in the siphon, and the minimum was equivalent to less than 1 ft. per second. At the blow-off connection a plank was found wedged.

Location	System	Obstacle	Year Built or Designed	Material of Pressure Conduits	Number of Conduits or Pipes	Diameter or Size of Each Conduit	Length in Feet	Drop or Available Static Head in Feet	Sewer Diameter and Slope: Above Siphon	Sewer Diameter and Slope: Below Siphon	Sump	Overflow or Blow-off	Special Provision for Cleaning Siphon	Reference
Aberdeen, Scotland	Combined	River Dee		Grouted tunnel, c. i. lining	2	6'6"×3'0"	344'	1.2	.....	.....	Lower end	None	Drain to sump and centrif. pump	Eng. and Contr. July 6, 1910, p. 13
Buenos Aires, Argentina	Separate and combined	River Riachuelo	1917	Tunnel with c. i. segments	1	7.54 ft.	443'	.....	.....	9.65'	.....	.....	.....	Eng. and Contr., Vol. 51, Feb. 12, 1919
Paris, Cichy	.....	River Seine	.....	Grouted tunnel, c. i. lining	1	7.54 ft.	1 519	.....	.....	.....	.....	.....	.....	Eng. Rec., Vol. 37, April 9, 1898, p. 409
Paris, Herbley	.....	.....	.....	Steel pipes	2	3.28 ft.	671.5	.....	.....	.....	.....	.....	.....	Eng. Rec., Vol. 37, April 9, 1898, p. 410
Binghamton, N. Y.	Mainly combined	River crossings	1916–1917	C. i. pipe in concrete	3	"	150' to 520'	.....	.....	.....	None	Both	Pressure water connection	Munic. Jour., Vol. 41, Dec. 15, 1916, p. 799
Carlisle, Pa.	.....	Letort Spring	1913	Vit. pipe in concrete	1	18"	52.5 ft.[1]	6.5	18"	18" at .00102	Both ends	None	Cute to creek	Eng. and Contr., Vol. 41, April 23, 1914, p. 508
Chicago, Ill.	Combined	Lawrence Ave. sewer	1907	Concrete	1	6'0"	30'	.....	.....	.....	None	None	None	Eng. and Contr., Vol. 27, May 22, 1907, p. 431
Hattiesburg, Miss.	Separate	Low ground and creek	1917	Vit. and c. i. pipe	1	8"?	2 860	1.0	.....	.....	None	None	Flushing connections	Eng. News-Rec., Vol. 80, Mar. 21, 1918, p. 569
Los Angeles, Cal., Sec. 3	Combined	.....	1895	Wood stave pipe	1	38"	3.4 mi. ≈	.....	3'4" 1:800	6'0" 1:800	None	Blow-off	.....	Eng. News, Feb. 28, 1895, also [4]
Sec. 6A	Combined	.....	1895	Wood stave pipe	1	30"	3.4 mi. ≈	.....	3'4" 1:800	3'4" 1:800	Upstream	Blow-off	.....	Eng. News, Feb. 28, 1895, also[4]
Louisville, Ky.														
Sec. A, Middle Fork Sewer	Combined	Beargrass Cr., So. Fork	1910	C. i. pipe in concrete	3	2–12", 1–36"	98 ≈	2.9	3'3" at 0.11%	3'3" at 0.11%	None	Overflow upper end	Valves for flushing	
Sec. B, Middle Fork Sewer	Combined	Beargrass Cr., Middle Fork	1910	Vit. pipe in concrete	3	12", 24", 30"	131.	0.47	3'0" at 0.11%	3'0" at 0.11%	None	Overflow upper end	Stop-planks for flushing	
Sec. D, Middle Fork Sewer	Combined	Beargrass Cr., Middle Fork	1912	C. i. pipe in concrete	3	12", 16", 20"	82.8	0.54	2'6 at 0.10%	2'6" at 0.10%	None	B. O. lower end, overflow	Inspection pit at lower end	
Sec. A, N. E. Sanit. Sewer	Separate	Beargrass Cr., Middle Fork	1910	Vit. pipe in concrete	3	18", 2–30"	819 ≈	0.53	3'3" at 0.10%	5'7½"×4'0" at 0.05%	None	Both	Spec. chambers at each end, at low point	
Sec. B, N. E. Sanit. Sewer	Separate	Edwards Pond Branch	1910	C. i. pipes in concrete	3	1–16", 2–20"	55	0.05	2'6" at 0.699%	2'6" at 0.10%	None	None	Stop-planks for flushing	
Sec. C, N. E. Sanit. Sewer	Separate	Edwards Pond Branch	1910	C. i. pipes in concrete	2	16", 20"	21 ≈	0.117	24" at 0.65%	24" at 0.65%	Upper end	Overflow upper end	Inspection chamber and manhole	Record drawings, J. B. F. Breed, Chf. Engr., and Harrison P. Eddy, Cons. Engr.
Enterprise Sewer	Combined	Beargrass Cr., Middle Fork	1911	Vit. pipes in concrete	2	10", 12"	86	0.59	6'0" with regulator	18"	None	Overflow upper end	Valves and chambers	
Cooper St. Sewer	Combined	Beargrass Cr., South Fork	1910	C. i. pipe in concrete	1	8"	133	2.3	3'0" with regulator	.....	None	Overflow upper end	Cleanout M. H. at low point	
Phoenix Hill Sewer	Combined	Beargrass Cr., South Fork	1910	C. i. pipe in concrete	1	8"	126	7.64	24" with regulator	.....	None	Overflow upper end	Cleanout M. H. at low point	
Brent St. Sewer	Combined	Beargrass Cr., South Fork	1911	C. i. pipe	1	16"	62	0.7	18" at 1.00%	18" at 0.96%	None	Overflow upper end	Spec. clean-out, inspection chambers	
Milwaukee, Wis.,														
High Level	Combined	Harbor	1916 et seq.	C. i. pipe and concrete	1	4'–0"?	6 482 horiz.	11.5 ≈	2–60"	4'83/6" open ch.	.....	.....	.....	
High Level	Combined	Harbor	1916 et seq.	C. i. pipe and con-rete	1	51", 60", 67", 72" approx.	6 430 horiz.	15.4 ≈	6'0" diam.	10'87/6" channel	.....	.....	.....	
High Level	Combined	River	1916 et seq.	Concrete	1[16]	2'0" to 6'9"≈	1 874 horiz	15.3 ≈	6'0"	60" c. i. pipe	.....	.....	.....	Sewerage Comn. drawings, T. Chalkley Hatton, Chief Engr.
Low Level	Combined	Harbor	1916 et seq.	Concrete	1	54" diam. ≈	798 horiz.	6.3 ≈	72"×48"	5'×10' channel	.....	.....	.....	
Low Level	Combined	Harbor	1916 et seq.	Concrete	1	42" diam. ≈	938 horiz.	6.8 ≈	68"×40"	.....	.....	.....	.....	
New Jersey Joint Outlet	Separate	Elizabeth River	.....	C. i. pipes	2	10"	95	15	24"	.....	None	.....	Valves and inspection M. H.'s	Eng. and Contr., Vol. 34, July 20, 1910, p. 67
New Orleans, La.	Separate	Third St. Drainage Canal	.....	18" c. i., 21" vit. pipe in concrete	2	2–18", 2–21"	40?	0.6	4'9"	4'9"	None	Overflow to canal	Valves and water for flushing	Jour. Assn. Eng. Soc., Vol. 27, 1901, p. 210
New Orleans, La.	Separate	Broad St. Drainage Canal	.....	Vit. pipe	2?	10"	92.5?	0.3	15", 12" and 10"	15"	None	None	Auto flush tanks	Jour. Assn. Eng. Soc., Vol. 27, 1901, p. 210
New Orleans, La.	Drainage Canal	Industrial Canal	Under construction	Reinforced concrete	3?	1–4'x10', 2–10'x13'	378	.....	.....	.....	None	.....	.....	Sci. Amer., Mar. 20, 1920, p. 304
Philadelphia, Pa.	Combined	Wissahickon Creek	.....	C. i. pipes	4	12", 2–16", 20"	152.5 horiz.	.....	3'6" at 0.31100	3'6"	Upper end	Blow-off	Inspection chamber and clean-out	Amer. Sew. Prac., Vol 1, p. 580
Providence, R. I.	Combined	Providence River	1895	Brick, steel casing	1	4'–0"	774	.....	.....	.....	Upper end	Overflow	.....	Eng. Rec., Vol. 34, July 25, 1896, p. 122, also City Engrs., Rept., 1895, p. 45
St. Louis, Mo	Combined	Street	.....	Reinforced concrete	2	8'x13'	600	.....	14' diam.	13' diam.	None	B. O. to old sewer	.....	Eng. News, Vol. 71, April 16, 1914, p. 839
Syracuse, N. Y.	Combined	Onondaga Cr. Channel	.....	8" and 10" c. i. pipe in concrete; 22" vit. pipe in concrete	3	8", 10", 22"	121 ≈	0.5	27"	27"	None	B. O. upper end	Flushing siphon, clean-outs, etc.	Contract drawings
Waterbury, Conn.	Separate	Naugatuck River	.....	Vit. pipe	3	10"	250 ≈	3.36	24"	21" at 0.25%	None	Overflow	Valves for flushing and M. H.'s	Eng. News, Vol. 59, March 26, 1908, p. 337

PLATE II
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
SEPTEMBER, 1921
COMMITTEE ON INVERTED SIPHONS.
FINAL REPORT.

≈, to c. of shafts.
Between shafts.
In c. of M. H.'s.
Eng. News, Feb. 10, 1898, p. 94; June 22, 1899, p. 389, June 14, 1906, p. 651.
There are four siphons of three lines each of same diameter pipe. 10", 16" and 18" sizes on different siphons.
On stoppage in 8 mos. operation.
Also a large public utilities duct.
48" c.i. pipe cast way and concrete conduit approx. equiv. 4'-0" circle.
Connection with preceding siphon
About 8 ft. of 2–60" pipe.

APPENDIX E.

Notes Relating to Certain Inverted Siphons Outside of Massachusetts.

The data tabulated in Appendix D relate to certain inverted siphons which have been selected as having special interest for one reason or another. Some are large structures in important systems, others are of the multiple conduit type with carefully designed regulating and inspection chambers, and still others were constructed by methods of special interest, particularly by tunneling.

Aberdeen, Scotland. This inverted siphon is of particular interest becasue of its size, about 6 ft. 6 in. in diameter, divided vertically by a division wall making two conduits each about 6 ft. 6 in. high by 3 ft. 0 in. wide and semi-circular in section. The siphon was constructed under considerable difficulty, using a cast-iron bolted lining which was grouted. A special sump at the lower ends is of interest because of the provision made for draining the siphon by means of a centrifugal pump installed for this purpose.

Paris, France. The two siphons listed are of interest not only because of their size and length, but particularly because of the construction methods adopted to overcome the difficulties encountered. One was constructed of steel pipes and the other was constructed in tunnel, using a cast-iron lining which was later grouted.

Buenos Aires, Argentina. This inverted siphon, which was constructed in 1919 by tunnel methods, involved the use of 557 tons (2 000 lbs.) of cast-iron segments for the lining. These segments were bolted together through flanges on the outside with joints broken longitudinally. A shield was used in the tunnel and compressed air was required to overcome the hydrostatic pressure. Two shafts, 14.75 ft. square, lined with concrete, inside a steel caisson, were sunk one on each side of the river, 443 ft. apart. The invert of the tunnel is about 58 ft. below

low water in the river. For a depth of about 51 ft. below the low-water line, the soil encountered was mud, below this was a bed of stiff clay, approximately 10 ft. thick, overlying beds of water-bearing sand.

Binghamton, New York. This three-pipe inverted siphon has inspection and clean-out chambers at each end on the straight run of the lower part of the siphon, designed so that access can be easily had to any part of the siphon for flushing or for cleaning with rods, as may be necessary. It also has an overflow to the river protected by a backwater gate. There are four such siphons on the intercepting sewer system, all of the same general type, but varying in the sizes of pipe used and in the length of the siphon. The reference given illustrates the siphon in considerable detail.

Carlisle, Pa. This inverted siphon has a 12-in. cast-iron pipe laid above the siphon, connected with the creek so that flushing water may be admitted to the siphon for flushing purposes.

Chicago, Ill. The Lawrence Ave. sewer is 16 ft. in inside diameter, constructed of several rings of brick. The siphon under this sewer is of unusual design, in that it is constructed on an arc having a radius of about 15 ft., rather than with two vertical shafts and a horizontal connection, as is the usual form of siphon. The siphon is illustrated in the reference given.

Hattiesburg, Miss. This 8-in. inverted siphon has a length of 2 860 ft., a maximum depth of 11 ft. below the inlet end, and a difference of 1 ft. in elevation between the invert at the inlet and at the outlet end. It gave no trouble during the first eight months of operation. It is stated that a flow of 40 000 gals. per 24 hrs. from the State Normal School appeared to maintain a self-cleansing velocity in the siphon. This rate in an 8-in. pipe will give a velocity somewhat less than 0.2 ft. per sec.

A tee and a shear valve were placed at the stream crossing to permit emptying the siphon, and for flushing with water from a near-by fire hydrant in case of clogging. About 300 ft. of the siphon beneath the creek bed was laid with cast-iron pipe, the remainder being vitrified clay pipe. The joints in the clay pipe were poured with "Jointite," and in the case of iron pipe with

lead. With no allowance for friction losses, the maximum hydrostatic head on the clay pipe is given as 9.5 ft.

Louisville, Kentucky. In 1907 work was begun on a comprehensive sewerage system for the city under the direction of the Commissioners of Sewerage, J. B. F. Breed, Chief Engineer, Harrison P. Eddy, Consulting Engineer. This work involved the construction of a number of stream crossings, built as inverted siphons. Ten of these are given in the tabulation in Appendix D.

The siphon in Section A of the Middle Fork sewer at the crossing of the South Fork of Beargrass Creek is illustrated in *Am. Sew. Prac.*, Vol. I, page 574, and is more or less typical of the general design adopted. Provision is made for carrying the dry-weather flow of sewage through one or both of the two 12-in. cast-iron pipe lines with an overflow dam permitting storm water to pass over and through the 36-in. cast-iron pipe. Control of these pipe lines is also maintained by means of valves and stop-planks.

The inverted siphon on Section B of the Middle Fork sewer follows the same general principle, but provides for the dry-weather flow in a single 12-in. pipe line, with a 24-in. and a 30-in. pipe line to care for the higher rates of sewage flow. Vitrified pipe encased in concrete was used instead of cast-iron pipe. A chamber with adjustable stop-planks was provided at each end of the siphon, so that dams can be formed at predetermined heights controlling the flow through the several conduits. An emergency overflow to the creek was also provided at the upper end. The maximum depression of the invert of the 30-in. pipe in this siphon was about 3.7 ft. below the invert of the sewer at the upper end, while the maximum depression in the preceding siphon was about 5.9 ft.

The inverted siphon on Section D of the Middle Fork sewer (see Fig. 7) has three conduits, 12-in., 16-in. and 20-in. in diameter respectively, all constructed of cast-iron pipe encased in concrete. Chambers at each end provide for control of the flow through the conduits, and at the inlet end there is an inspection chamber by which access can be had to the horizontal run of the three conduits at their lowest point. There is also an emergency overflow in this chamber. The maximum depression of the invert

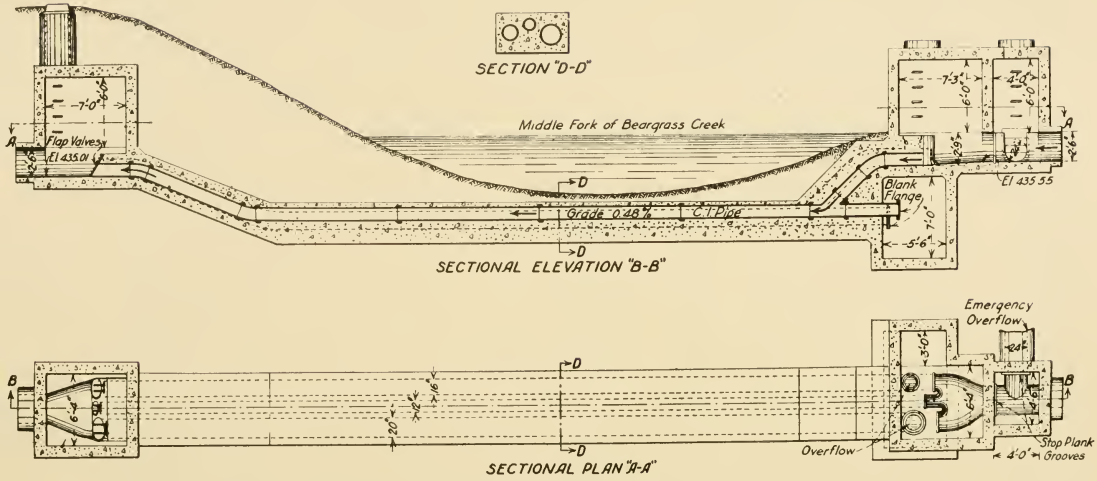


FIG. 7. — SEC. D MIDDLE FORK SEWER SIPHON, LOUISVILLE, KY.

of the 20-in. pipe below the invert of the sewer at the upper end is about 5.5 ft.

In designing all three of these siphons, it was intended that the smallest pipe be used as long as it has sufficient capacity to provide for the quantity of sewage flowing. When this capacity is overtaxed, it is expected that the flow will be transferred to the next larger pipe, which will be continued in use until such time as its capacity is overtaxed, when the largest pipe will be put into service and the other two temporarily thrown out of use. Later on, two or more pipes can be placed in service, so that at all times it should be possible to provide sufficient velocity through the siphon to prevent deposit. Thus far experience has shown that this is the case.

There are three inverted siphons on the Northeastern Sanitary Trunk sewer carrying sewage from a separate system. The inverted siphon on Section A is illustrated in *Am. Sew. Prac.*, Vol. I, Fig. 248, p. 574. Also in the report of the Commissioners of Sewerage, Jan., 1910, pp. 65 and 147. It consists of three lines of vitrified pipe encased in concrete, one 18-in., and two 30-in. These pipes are so graded that when the sewage is shut off they will drain to one low point in the creek bed where a clean-out chamber has been constructed. Control-valves and stop-planks have been provided for the operation of the siphon in the manner previously described. The maximum depression of the invert of the 30-in. pipe is about 15 ft. below the elevation of the invert of the sewer at the inlet end.

The inverted siphon on Section B of the Northeastern Sanitary Trunk sewer has three lines of cast-iron pipe encased in concrete, a 16-in. and two 20-in.

There is no depression in the invert of this siphon, but the crown is depressed to a maximum of 14 ins., because of the change from a 30-in. sewer above and below the siphon to the 16-in. pipe, where the siphon crosses under the bed of Edwards Pond branch. Special chambers have been provided at each end of the pipe lines with stop-planks for controlling the flow, as previously described.

The inverted siphon on Section C of the Northeastern Sanitary Trunk sewer is somewhat similar, but the maximum depres-

sion of the invert is about 16 ins. The sewer above and below the siphon is 24 ins. in diameter and the crossing under the creek is made in two cast-iron pipes, one 16-in. and a 20-in. There is a manhole at each end for inspection and cleaning purposes, but no regulating stop-planks or gates. An overflow to the creek is provided at the upper end.

There is an inverted siphon on the Enterprise sewer connection where it crosses under Beargrass Creek. The dry-weather flow in the 6-ft. diameter brick sewer is diverted by means of a dam, two ft. high, into a regulator chamber controlled by a float-operated regulating valve which discharges into one or both of two vitrified pipe lines encased in concrete. One line is 10 ins. in diameter and the other 12 ins. At the outlet end there is a chamber in which the vitrified pipe can be removed and access gained to the horizontal run of the siphon for cleaning and inspection. The maximum depression of the invert of the 12-in. pipe in this siphon below the invert of the Enterprise sewer is about 7.5 ft. Sliding gates have been provided at the inlet end of each pipe and a flap valve at the outlet end, so that either or both of the pipes may be placed in operation at any time. In addition, a branch pipe leading from each siphon pipe in the regulating chamber and below the sliding gate allows an overflow into the second pipe when only one is in commission.

An inverted siphon was necessary to carry the Cooper St. sewer connection under the improved channel of Beargrass Creek. This siphon consists of one 8-in. vitrified pipe encased in concrete. The maximum depression of the invert is about 6.6 ft. below the invert of the sewer at the upper end. Near the outlet end a clean-out manhole has been built, with a gate valve to shut off the flow when cleaning the siphon. The flow into the siphon connection is controlled by a float-operated regulating valve. A drawing of this inverted siphon is given in the report of the Commissioners of Sewerage, March 1913, p. 92.

An inverted siphon was required to carry the Phœnix Hill sewer connection under Beargrass Creek to the Beargrass intercepter. Sewage from the Phœnix Hill sewer is diverted into a regulator manhole, and the flow controlled by a float-operated regulating valve, discharging into an 8-in. cast-iron pipe encased

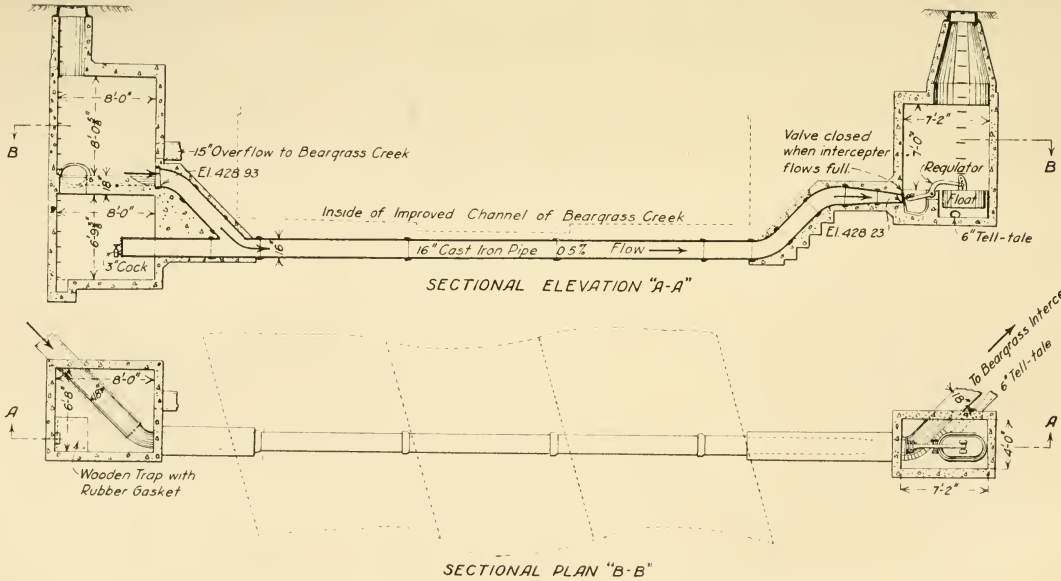


FIG. 8. — BRENT ST. AND BROADWAY SEWER CONNECTION UNDER BEARGRASS CREEK, LOUISVILLE, KY.

in concrete. Near the discharge end is a valve and clean-out manhole in which a section of pipe can be removed in case it is necessary to put rods into the pipe. This design is similar to that of the Cooper St. sewer siphon. The invert of the siphon at the lowest point is depressed about 4 ft. below the invert of the siphon at the inlet end, and about 10 ft. below the invert of the sewer beyond the regulator chamber.

The Brent St. and Broadway sewers are connected to Beargrass Creek through a 16-in. cast-iron pipe inverted siphon (see Fig. 8). The pipe has been depressed a sufficient amount, about 4.8 ft. maximum, to clear the inside of the proposed concrete channel for Beargrass Creek. The discharge into the siphon is controlled by a regulating valve, float operated, set in a regulator chamber similar to the design of the Cooper St. and Phœnix Hill siphons. At the discharge end of the siphon is an inspection chamber with a clean-out leading directly into the horizontal run of the siphon. Access to the inspection chamber is had through a manhole in the discharge chamber of the siphon.

Milwaukee, Wisconsin. There are a number of inverted siphons on the intercepting sewers leading to the Jones Island Sewage treatment plant. The following description includes five, of which three are high-level siphons and two low level. The low-level siphons discharge into the suction wells of the low-lift pumping station, whereas the high-level siphons discharge directly into the sewage treatment plant, with the exception of one, which is under the Milwaukee river and discharges into one of the other siphons leading to the treatment plant site.

The high-level siphon from Second and Scott Sts. to Jones Island begins as a 48-in. cast-iron pipe with invert at the inlet end at approximately El. 14.6 and extends for a length of 5 684 ft. to the foot of Park St., where the invert elevation is approximately minus 10.2. The siphon then drops vertically in a concrete shaft having a wetted area of 12.92 sq. ft. and a wetted perimeter of 13.46 sq. ft. to El. minus 54, then continues in a concrete tunnel having a wetted area of 12.51 sq. ft. and a wetted perimeter of 10.14 ft., a distance of 798 ft. to Jones Island, where the invert elevation is approximately minus 55. The siphon then rises in a shaft 48 in. in diameter, constructed of concrete,

to an open channel 4 ft. wide by 5 ft. 6 in. deep to an invert elevation of approximately plus 4.5. The two 60-in. diameter conduits at the inlet end of the siphon have an invert elevation of approximately 15.5, and there is provision for a future connection 54 in. in diameter at approximately El. 14.6.

The high-level inverted siphon from Mason and Broadway to Jones Island begins as a shaft in the 72-in. diameter sewer, invert elevation approximately 19.4. The shaft has a wetted area of 24.5 sq. ft. and a wetted perimeter of 18.83 sq. ft. The elevation of the invert at the bottom of the shaft is approximately minus 7.6, from which point the siphon continues as a tunnel 51 in. in diameter, constructed of concrete, a distance of 1 822 ft. to Detroit St. and Broadway, where the inverted siphon from Eighth and Sycamore Sts. enters as above referred to. The elevation at this point is approximately minus 8.2, and the size of the tunnel is increased to 60 in. in diameter, constructed of cast iron. This section of the inverted siphon extends for a length of 3 679 ft. to the foot of Erie St., invert elevation approximately minus 9.8, at the head of a shaft constructed of concrete having a wetted area of 28.13 sq. ft. and a wetted perimeter of 19.54 ft. The shaft drops to elevation approximately minus 55.8 and then extends a distance of 938 ft. under the harbor in a concrete tunnel of special section having a wetted area of 28.39 sq. ft. and a wetted perimeter of 19.81 ft., to invert elevation approximately minus 56.9. The inverted siphon then rises in a 72-in. diameter concrete shaft to an open channel 10 ft. wide by 7 ft. 6 in. high, with an invert elevation of plus 2.50. The connection for a future 60-in. cast-iron pipe has been provided at the foot of Erie St.

The high-level inverted siphon from Eighth and Sycamore Sts. to the siphon at Broadway and Detroit St., above described, begins at Eighth St. in the 72-in. diameter sewer, invert elevation approximately 18.9, and extends a distance of 1 443 ft. to Sixth and Claybourne Sts., invert elevation approximately 11.7, to a concrete shaft having a wetted area of 40.0 sq. ft. and a wetted perimeter of 26.0 ft. The shaft drops to elevation plus 1.0, and then the inverted siphon continues as a 72-in. diameter concrete structure, a distance of 2 407 ft., to the concrete shaft at West

Water and Tyler Sts., invert elevation approximately minus 10.8. The shaft has a wetted area of 36.0 sq. ft. and a wetted perimeter of 24.0 ft. The shaft drops to elevation approximmately minus 45.2, from which point the inverted siphon continues in a special section having a wetted area of 28.4 sq. ft. and a wetted perimeter of 20.51 ft., a distance of 1 024 ft., to Broadway and Detroit St. Here there are two vertical shafts, 60 in. in diameter each, constructed of concrete, rising from elevation approximately minus 21.2 to elevation approximately minus 8.2 to the connection with the siphon previously described.

The two low-level inverted siphons are of a different type, consisting, in each case, of two vertical shafts connected at the bottom by a tunnel built on a flat grade.

In the case of the siphon at the foot of Park St. the shafts are constructed of concrete 54 ins. in diameter and the connecting tunnel is of concrete of a circular section having a wetted area of 16.2 sq. ft. and a wetted perimeter of 15.0 ft. The invert elevation at the bottom of each shaft is approximately minus 59 and minus 60 respectively.

The low-level inverted siphon at the foot of Erie St. has shafts 42 ins. in diameter of concrete and a connecting tunnel of concrete having a wetted area of 9.6 sq. ft. and a wetted perimeter of 11.83 ft. The invert elevations of the tunnel are approximately minus 60.8 and minus 61.8 respectively. Both of these low-level siphons connect at Jones Island into a common channel 5 ft. wide by 10 ft. deep leading to the low-level pumping station. The invert elevation of this channel is approximately minus 22.0 and the flow line may be estimated as El. minus 18.0. The elevation of the invert of the 72 in. by 48 in. sewer at the foot of Park St. is approximately El. minus 17, and the elevation of the invert of the 68-in. by 49-in. sewer at the foot of Erie St. is approximately El. minus 15.8.

A number of inverted siphons are illustrated and described briefly in the fourth annual report of the Milwaukee Sewerage Commission, January, 1918.

New Jersey Joint Outlet. This siphon under the Elizabeth river, constructed with two 10-in. cast-iron pipes, has special chambers at each end providing for inspection and cleaning of the

pipes. The horizontal run of the siphon pipes has been extended in each direction to enter these inspection chambers. The siphon is well illustrated in the reference given.

New Orleans, La. There are a number of inverted siphons in the New Orleans sewerage system, due to the necessity of frequent crossings of the drainage canals.

One of these siphons is of a different type than the others, and is therefore of particular interest. This one occurs on the main sewer at the crossing of the Third St. canal. In this case the invert of the sewer is about 21 ins. below the bottom of the drainage canal. Two 18-in. cast-iron pipes are laid on a straight line under the drainage canal, and these are of sufficient capacity to carry the minimum flow of the sewer. When the amount of sewage increases to overcharge these two pipes, the sewage will overflow into two 21-in. vitrified pipes laid in concrete as a siphon immediately under the 18-in. pipes. Provision has been made for flushing the 21-in. pipes, and there is an overflow into the drainage canal for use in case of stoppage in the pipes or sewer.

The other siphons are of the more usual type constructed of vitrified pipe encased in concrete and have automatic flush tanks which thoroughly flush out the pipes each day. Details of these siphons are given in the reference.

The large inverted siphon under the Industrial canal, carrying the Florida Ave. drainage canal, has already been referred to in the text of the report.

Philadelphia, Pa. The inverted siphon under Wissahickon Creek is of interest because of the regulating valves used, and the special provision for flushing and inspection of the horizontal run of the pipes. The siphon was constructed with four lines of cast-iron pipe, a 12-in., two 16-in., and a 20-in. The inlet end are provided with gates so that only those pipes will be in service which are required to carry the flow at a suitable velocity. The outlet end of each pipe is provided with a flap valve of special design, and the inspection opening to each pipe has a flap valve of similar type with a hose connection. This siphon is well illustrated in the reference.

It will be noted that with this form of inverted siphon there is no provision for the automatic regulation of the flow into one

or more pipes. It is intended that the flow shall be controlled by opening or closing valves from time to time, as the quantity of sewage increases, so that desirable velocities will be maintained at all times in the siphon.

St. Louis, Mo. A reinforced concrete inverted siphon of unusual type, designed to carry 2 090 cu. ft. per sec., was constructed at St. Louis at a point where the hydraulic gradient lies above the street level for several hundred feet, the maximum height being about 4 ft. The sewer, 14-ft. in diameter, is increased to a 14-ft. square section in a length of 16 ft., then comes 25-ft. of reinforced concrete section changing from the 14-ft. square section to a section 8 ft. by 27 ft., with a center wall 12 in. wide, forming a double box flume 550 ft. long, having two conduits, each 8 ft. high by 13 ft. wide. Beyond this is a 25-ft. section changing back to the 14-ft. square, and then a 16-ft. reduction section to the old 14-ft. diameter sewer. This siphon is illustrated in the reference given.

Syracuse, New York. An interesting inverted siphon has been constructed where the main intercepting sewer crosses under the improved channel of Onondaga Creek (see Fig. 9). The siphon consists of three pipes laid in concrete, 8-in. 10-in. and 22-in. in diameter respectively. The main sewer is 27 ins. in diameter above and below the crossing. The inlet ends of the 8-in. and 10-in. pipes are provided with blank flanges, so that either one or both of the pipes may be put into use as desired. The flow into the 22-in. pipe is controlled by a flushing siphon, 24-in. size, similar to that used in dosing intermittent sand filters or trickling filters in sewage treatment plants. The flushing siphon has a drawing depth of about 13 ins. The vent of the flushing siphon extends for only a short distance above the maximum flow line, and serves as an overflow in case of failure of the flushing siphon to operate, or in case either of the other two pipe lines become clogged.

For the first few years of operation, the capacity of the 8-in. pipe was expected to be sufficient to carry the flow, and the 10-in. was stopped at each end. During times of storm, when the flow was too large for the 8-in. pipe, the sewage backed up in the main sewer until the siphon on the 22-in. pipe came into action, causing

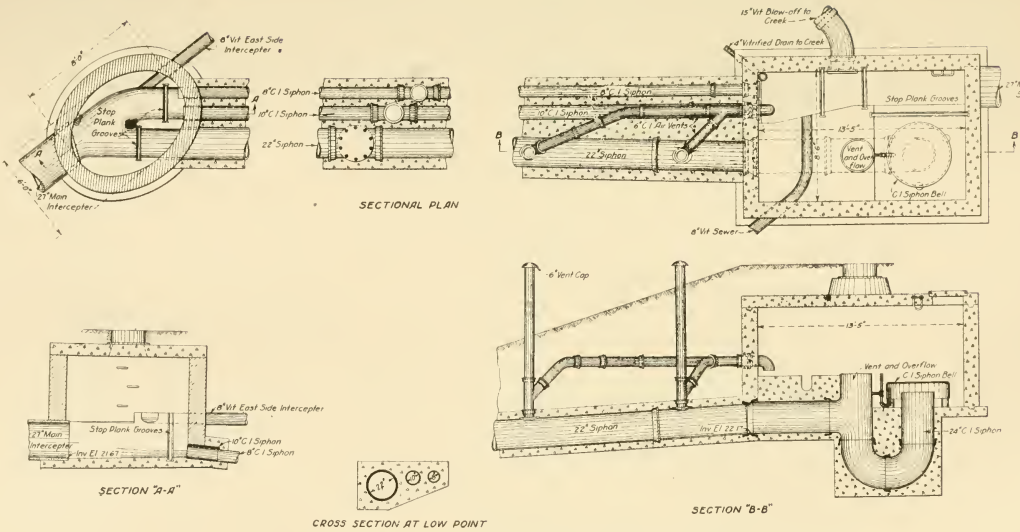


FIG. 9. — MAIN INTERCEPTING SEWER SIPHON, SYRACUSE, N. Y.

the surplus flow to be discharged through the 22-in. pipe in doses at a sufficiently high velocity to keep the pipe clean.

When the quantity of sewage exceeds the capacity of the 8-in. pipe, the 10-in. can be put into service instead of the 8-in., and at some future time, when needed, both pipes can be kept in service.

This structure was constructed under the supervision of the Syracuse Intercepting Sewer Board, Glenn D. Holmes, Chief Engineer.

Waterbury, Conn. The Eagle St. siphon was designed to carry the sewage from the 24-in. main sewer under the Naugatuck river. The siphon is constructed of three 10-in. vitrified pipes encased in concrete. The maximum depression of the pipes line under the river is about 8.7 ft. below the invert of the trunk sewer at the entrance. The entrance to each of the three pipe lines is controlled by stop-planks and a flap valve, so that one, two or three of the pipe lines may be brought into service as required by the flow of sewage. Each of the lines may be flushed out by closing the flap valves, filling the manhole with water from a pressure water connection, opening one of the flap valves, and causing the pipe line controlled by that valve to be flushed out at a velocity sufficient to clean out any ordinary deposit in the pipe line.

The details of this siphon are illustrated in the reference given.

APPENDIX F.

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MEMOIR OF DECEASED MEMBER.

EDMUND MORTIMER BLAKE.*

EDMUND MORTIMER BLAKE died at his home in Oakland, California, January 12, 1921. The prominent part taken by Mr. Blake in the Boston Society of Civil Engineers, of which he became a member April 20, 1904, the splendid work accomplished by him in this Society, and, still more, the strong and sincere personal friendship with all the members with whom he came in contact, will make the events of his life of unusual interest.

" Ned " Blake was born in Taunton, Massachusetts, August 13th, 1874, the son of Percy M., a past member of this Society, and Phœbe Sheffield Blake, and was educated in the public schools of Hyde Park, *Amherst College*, class of 1897, Degree Bachelor of Science, Magna Cum Laude, *Harvard University*, Lawrence Scientific School, class of 1899, B. S. in Civil Engineering, Magna Cum Laude.

His early work as a Civil Engineer was as associate with his father, during which time he took charge of the construction of the Sebago Basin for the Portland, Maine, Water Company, this work having been pronounced by competent judges the finest work of its kind ever constructed in Maine.

He was Assistant Engineer, New York Rapid Transit Commission, Eastern Bridge and Structural Company, Worcester, and Brown Hoisting Machinery Company, Cleveland, Ohio.

From 1906 to 1908 Mr. Blake carried on a private practice in sanitary and water-works engineering, designing and installing systems at Wareham, Wrentham, Westford, Hampton Beach, New Hampshire, and the new plant at Provincetown. He organized and was the first President of the Westford, Mass., Water Company.

* Memoir prepared by Henry A. Symonds and N. L. Hammond.

In 1908, Mr. Blake was called to become Manager of the Idaho Irrigation Company, which constructed and developed large irrigation projects, in the Snake River territory, to reclaim the vast tracts of the Idaho desert lands. He also carried on a private practice and installed several town water, irrigation and sewerage works in Idaho, Washington and Oregon.

In 1911, he was called back to Massachusetts, by the State Department of Health, to become engineer in charge of the twelve miles of improvement on the Neponset River.

This work was followed by an engagement on the South Boston Dry Dock, with the Holbrook, Cabot and Rollins Corporation.

When construction of the United States Naval Destroyer Plant at Squantum was begun in 1918, by the Aberthaw Construction Company, Mr. Blake was appointed supervisor of sub-contracts, having charge of work totaling approximately three million dollars.

This work was followed by that of Manager of Sub-contracts in the addition to the plant of the Bethlehem Shipbuilding Corporation at Sparrows Point, Maryland, whence he was transferred in the same year to the Liberty Shipyard of the Emergency Fleet Corporation, at Alameda, California, where he was advanced to Assistant Manager.

While acting in this capacity he placed a contract for forty-eight thousand green piles, the largest single order ever given. During this engagement he handled successfully many difficult problems, requiring great executive ability, and completed his work there, after the abandonment of the yard project by the Government, on the signing of the armistice, by the satisfactory adjustment of twenty-nine claims outstanding.

In December, 1918, Mr. Blake became associated as Production Engineer with Charles R. McCormack and Company, of San Francisco, one of the largest operators in the Douglas Fir Timber industry. His work with this Company had developed to great magnitude and importance.

Putting into this work the intense enthusiasm and energy he had displayed in all his efforts, the opportunity appeared to

have arrived for the realization of his purpose for great accomplishment.

He was instrumental in organizing the National Association of Tie Producers, in 1919, and was elected President for 1921.

Was member of committee to consult with the officials of the Railroad Administration at Washington on matter of fixing prices and territorial restrictions of markets.

Mr. Blake delivered papers upon various phases of the production and preservation of timber, before the National Association of Tie Producers, Boston Society of Civil Engineers, American Wood Preservers Association, the San Francisco Association of Members of the American Society of Civil Engineers, and others. Membership in Societies included Alpha Delta Phi and Phi Beta Kappa Chapters of Amherst College. He married, in 1903, Clara Allen Drake, of Cleveland, who died in 1907.

While in Idaho, he married Miss Grace Twiggs, and has one son, Robert Sheffield Blake, eight years old.

He also leaves his father, Percy M. Blake, of Newtonville, a brother, Philip W. Blake, Secretary of the Chamber of Commerce, Cumberland, Maryland, and two sisters, Mrs. Andrew A. Highlands, of Brookline and Mrs. Frederic A. Tennant of Newtonville.

Many papers have been read and published by Mr. Blake in the various engineering periodicals.

He published successfully a novel, "In The Blake Forest," in 1896. His great versatility is made evident by remarkable success in music, being an accomplished musician and composer. In the latter field he composed many of the most popular pieces of the Amherst College music.

In personal appreciation we wish to quote Mr. E. E. Pershall, of the National Association of Tie Producers, at the Chicago Convention in 1920:

"I do want to say this, Blake has certainly stood out as one of the biggest personalities that this Tie Association has brought together. We didn't know Blake before we had the Tie Association. If I didn't get another thing out of this Association but just meeting E. M. Blake, I would feel that all the work

in getting this Association together and everything that we have striven for, and all our efforts in trying to reconcile all the petty things that have come up, was more than justified and that I was well repaid.

He came out of the West. We know the company by reputation only, we never had any competition with them, and Blake has been the outstanding discovery of this Association."

Former Attorney-General Ralph A. Stewart says, "I desire to express to the Boston Society of Civil Engineers a word of appreciation. I knew Mr. Blake for many years, and, during the time he practiced his profession in Massachusetts, intimately. He was a man of splendid ability, fine professional attainments and unbounded enthusiasm. He worked with me in several professional matters, and I learned to know that I could place great reliance upon his judgment, and furthermore his work was thorough and reliable. He was a most engaging man to work with, for he injected into any professional employment enthusiasm and optimism. We became warm friends, and the news of his death came to me as a real sorrow."

In 1916, "Ned" Blake presented a very strong paper "Service for the Society," in which his own enthusiasm and loyalty to the Society and to the profession is evident in every line. It is a fine, clear statement, which should be carefully read and re-read by our members.

There is little to be added, as deeds speak for themselves.

His "Service for the Society," to his friends and to his country have left a lasting influence for the best.

To a legion of friends, the memory of his laughing eyes, his quick sympathy, his generous helpfulness, will remain a rich legacy from that prince of good fellows, Ned Blake.



Samuel Everett Tinkham,
Secretary, Boston Society of Civil Engineers,
April 20, 1880 — December 20, 1882, and May 18, 1887 — April 21, 1921.
Died April 21, 1921.

Vol. VIII OCTOBER, 1921 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

IN MEMORY OF SAMUEL E. TINKHAM.

NOTE. — At the regular meeting of the Society, held September 21, 1921, which was devoted to the memory of Mr. Tinkham, the following papers commemorating the varied activities of his life were presented.

SAMUEL EVERETT TINKHAM.

BY EDWARD W. HOWE, Past President, Boston Society Civil Engineers.*

SAMUEL EVERETT TINKHAM, for nearly thirty-seven years the Secretary of our Society, was born in Taunton, Mass., March 31, 1852, and died at his home in Roxbury, April 21, 1921.

He attended a meeting of the Board of Government on the afternoon preceding the regular April meeting of the Society on April 20, and during the interim between the two meetings, while at dinner at the City Club, he was suddenly overcome by an apoplectic shock. He was removed to his home in the Roxbury district, where he lingered in an unconscious condition until the evening of the following day, when he died.

Mr. Tinkham was a descendant in the eighth generation from Ephraim Tinkham, who while a minor came to Plymouth, Mass., in 1632, as an apprentice to Timothy Hatherly, one of the financial promoters of the infant colony, who, although not a passenger in the *Mayflower*, made two or more voyages to New England before finally settling in what is now Scituate, Mass.

In 1634 Hatherly transferred his apprentice to John Winslow.

* 26 Wayne Street, Grove Hall Station, Boston, Mass.

In 1642 young Tinkham, having probably become of age, for his services as an apprentice was given a grant of land, and before 1647 he married Mary, the daughter of Peter Browne, who came as a single man in the *Mayflower*, thus making all of the Tinkham family "*Mayflower* descendants." This, however, is not the only claim by which our friend and associate had that title, for we have been able to trace different lines of his ancestors to no less than six of the *Mayflower* Pilgrims. In addition to Peter Browne, he was descended from Richard Warren and Thomas Rogers, in the Tinkham line, and from Stephen Hopkins, George Soule and Francis Cooke, the latter in two lines, on the Ellis side, all of whom landed on Plymouth Rock from the *Mayflower* on that memorable day, December 21, 1620. There is reason to believe that, if time for the search had permitted, still others of that company would have been found among his progenitors.

Ephraim Tinkham appears to have been a man of some prominence in the communities where he lived. The Plymouth Colony records show that in 1656 he was one of the "Survayors of Highwaies," and mention is made several times in the records of his appointment to settle boundary disputes between estates. Perhaps this occupation may have had an influence through inheritance upon the choice of a profession by our fellow-member.

Ephraim Tinkham in 1666 is given, in records, the title of "sergeant." In 1669 he became one of the original proprietors or grantees of the town of Middleboro, Mass., and removed there and built a home; but in 1675, "King Philip's War" having broken out, the settlement was destroyed by the Indians and the inhabitants returned to Plymouth. In 1679 they returned to their grants. Ephraim's will was approved on June 5, 1685, and gives his children lands in Plymouth and Middleboro. His son Ebenezer lived in Middleboro, and the Tinkham line comes down from him through Jeremiah—Jeremiah—Elisha—Jeremiah to Samuel Miller Tinkham, the father of our late Secretary, all of them after Ebenezer, who was born in Plymouth, having been born in Middleboro.

Samuel Miller Tinkham was interested in early life in mechanical pursuits, and was the treasurer of the Taunton Foundry

and Machine Company. One of the productions of that company was the making of metal frames for pianos for the Chickering Company. Through acquaintances thus formed he was led to establish a music store in Taunton, which he carried on for many years.

Mr. Tinkham married, first, Miss Celia Ellis, of Plymouth, Mass., the daughter of Josiah Thompson and Sophia (Wright) Ellis and grandaughter of Sergeant Stephen Ellis, who was a soldier in the American Revolution. She was a descendant in the seventh generation from John Ellis, an early settler in Sandwich, Mass.

Mrs. Tinkham died when Everett was three years old and left four sons, one daughter having died in infancy. Not long after, the father married Miss Margaret E. Bright, who became as devoted to her husband's children as though they were her own. She had been a school teacher, and fully appreciated the value of a good education. We are told that she was accustomed to gather the boys around her in the evenings and study with them English history and read the stories of Charles Dickens.

It was through her persistence and help that Everett, after passing through the common schools and being instructed by a private tutor, was enabled to prepare himself for entering the Massachusetts Institute of Technology, becoming a member of the class of 1873. After graduating he was employed for a short time on the construction of a bridge at Cohoes, N. Y., and in the spring of 1874 he entered the office of the city engineer of Boston.

He was a member of the old First Church in Roxbury, of which John Eliot, the apostle to the Indians, was the first minister. For some years Mr. Tinkham was the chairman of the standing committee of the church. He was a member of the Sons of the American Revolution, and was greatly interested in Masonry.

Mr. Tinkham married, October 20, 1879, Miss Louisa W. Danforth, daughter of Charles J. and Sarah E. Danforth, of Roxbury. He is survived by her and by three children, namely, Charles S. Tinkham, resident engineer of the Massachusetts Highway Commission at Greenfield, Mass.; Frank B. Tinkham, in business in Boston, and Louise Danforth Tinkham, the wife of Leo Twombly, of East Orange, N. J.

Mr. Tinkham's engineering career, his work for the Society and in the Masonic body, will be described by others who will speak to you.

His funeral was conducted in the old Roxbury church, on Sunday afternoon, April 24, by the minister, Rev. Miles Hanson, and by Joseph Warren Commandery Knights Templars, and was very largely attended.

Associated as I was with Mr. Tinkham for nearly forty years in the City Engineer's Department of Boston, though not on the same work, and for sixteen years in the Board of Government of this Society, I cannot forbear, in closing, expressing my personal regard for him as a friend and my appreciation of his splendid character as a man. He was always a genial companion and ready with any assistance he could give. The City never had a more faithful and conscientious servant, nor our Society a more devoted, able and self-sacrificing officer.

S. E. TINKHAM'S CONNECTION WITH THE BOSTON SOCIETY OF CIVIL ENGINEERS AS ITS SECRETARY FOR THIRTY-SEVEN YEARS.

By Desmond FitzGerald, Past President, Boston Society Civil Engineers.*

I have been asked to say a few words in regard to Mr. Tinkham's connection with this Society as its Secretary for many years. While it is an impossible task for any one to do justice to that connection, or to draw a picture which will adequately portray our feelings as we try to think of the Society without his guiding hand, it is one which we must attempt.

In 1873 a Boston Society of Civil Engineers was organized at the Massachusetts Institute of Technology, and of that society Mr. George S. Rice was the secretary. In 1874 the original society of 1848 was revived, and of that society Mr. Samuel Nott was secretary. He resigned and George S. Rice was elected to the office. After Mr. Rice's resignation, Mr. Tinkham, on April 21, 1880, was elected to the office. In 1882 a change came in Mr. Tinkham's business connections and he was

* Brookline, Mass.

obliged to resign. In accepting the resignation the following resolutions were adopted:

"*Resolved*, that the Boston Society of Civil Engineers fully recognizes its obligations to Mr. S. E. Tinkham, its late Secretary, for his efficient services in maintaining its general interests and providing entertainments at its monthly meetings, and for his efforts for the success of the Journal of the Association of Engineering Societies, and that it deeply regrets the resignation of the position he has so creditably and acceptably occupied.

"*Resolved*, that in evidence of the appreciation by the Society of Mr. Tinkham's services, these resolutions and the accompanying votes be entered upon the records of the Society and communicated to Mr. Tinkham, with an invitation to attend the approaching annual dinner of the Society, as a guest.

"*Voted*, that Mr. Tinkham's dues to the Society for the present and next financial years be remitted.

"*Voted*, that the Treasurer be authorized and directed to pay Mr. Tinkham the sum of fifty dollars as a further indication of the feeling expressed in the foregoing resolutions."

Between 1882 and 1887 the duties of Secretary devolved upon Mr. Horace L. Eaton. On his relinquishment of the office, Mr. Tinkham again became Secretary, which office he filled until his death, April 22, 1921, when that sudden call came to our friend to enter the higher life.

Thus for thirty-seven years S. E. Tinkham filled the office of Secretary. How well he filled it we all know.

The services of our friend in the early days were of quite a different nature from those which came later, when the Society had outgrown its early proportions.

Money, in those early days, was extremely scarce. Even in 1877, the Secretary was directed to ascertain the cost of printing a list of members, and report the expense. The chief problem then was, how to keep the society together, to coördinate the interests of the members and bring them into social as well as professional friendship. This was a duty for which Mr. Tinkham was well qualified. In all the wanderings of the Society, from the time when the library was kept in a single dry-goods box to the days of its present magnitude, Mr. Tinkham's cheerful and cordial interests were ever exerted for the advantages and enlargement of the Society. He had a friendly greeting for every

new member, and he never lost an opportunity to bring all the various branches of the profession into a closer union.

In the beginning, the Secretary was required by the constitution to keep an accurate record of all the transactions of the Society, notify all members of meetings, and issue all notices. The constitution was amended in 1879, and under its provisions the Secretary was required to have a list of members entitled to vote and forms of notices to be sent to members. He was also required to send an abstract of the proceedings of the previous meeting with the notices. Under the latest form, "the Secretary, under direction of the President and Board of Government, shall be the executive officer of the Society. He shall keep records of all meetings of the Society and of the Board of Government, shall receive all fees, dues and other moneys due the Society (except the income of the permanent fund), and transmit the same monthly to the Treasurer." He was also required to notify delinquents.

After all, it was not so much the numerous and delicate duties in every direction, "day in and day out" and "year in and year out," which fell to Mr. Tinkham's lot, as the spirit in which those duties were fulfilled. Measured by this standard, our faithful Secretary could not be found wanting. At one moment a new member was conducted into the field and in due time shown how he could aid the Society; at another, some older member, perhaps a little delinquent, required to be stimulated to fall into line and assume some share of the common load. Mr. Tinkham's nature seemed to possess an unlimited supply of good temper and discriminating knowledge amid all the varying conditions of a large and ever-increasing membership. He had the happy faculty of understanding the special resources of each member of the Society, and he knew best how to direct and control those resources for the benefit of all.

The Society, in its chequered career, has had many officers and members who have contributed to its usefulness and renown, but among them was one whose name leads all the rest, and the good which S. E. Tinkham accomplished for the Society will endure as long as the Society exists.

SAMUEL EVERETT TINKHAM: HIS SERVICES AS AN ENGINEER.

By Frederic H. Fay, Past President, Boston Society of Civil Engineers.*

Samuel Everett Tinkham received his educational training as a civil engineer at the Massachusetts Institute of Technology, where he was graduated in 1873, at the age of twenty-one. Prior to his graduation, he had been employed during the summer vacation of 1872 in active field work as a rodman in the engineering department of the New York State Canals. After his graduation from Technology, he was appointed, in the summer of 1873, an assistant in the corps of Engineers, United States Army, and for more than a year was employed on harbor improvements at Edgartown, Mass.

In October, 1874, he was given a temporary appointment as transitman in the city engineer's office, Boston, on work which was expected to last about six weeks but which in reality lasted his whole lifetime, except for one brief interval. On his first day in the city engineer's office, while waiting for an assignment of work in the temporary absence of the city engineer, Mr. Wightman, he made the acquaintance of the chief clerk, who according to custom was copying, long-hand, a contract to accompany printed specifications. Mr. Tinkham eagerly accepted the invitation of the chief clerk to assist in this work; so it was that Mr. Tinkham's first work for the City was the laborious long-hand copying of a contract. To the younger members of the Society who take as a matter of course typewriting and stenography and modern office conveniences, this instance may give some idea of the length of Mr. Tinkham's service when they consider that its beginning antedated the typewriter and modern stenographic methods.

In those days, too, it was the practice to make an original contract drawing in India ink, on mounted white paper. Duplicates of contract drawings were obtained only by tracing them in India ink on tracing cloth, a process very laborious and expensive and extremely difficult to keep free from errors. Early in Mr. Tinkham's period of service for the City, Mr. Wightman, the city engineer, learned of the newly suggested blue-print

* Fay, Spofford & Thorndike, 15 Beacon Street, Boston, Mass.

process, thought it looked practicable and economical, and turned it over to Mr. Tinkham to work up. The latter bought and mixed the chemicals, coated the paper, took the prints, and throughout experimented with materials, apparatus and processes, getting more and more reliable results. He, therefore, was one of the early engineers to develop to a practicable working basis the modern process of reproduction by blue-printing.

Mr. Tinkham's service for the City of Boston was divided into two periods, the first, eight years in duration, from 1874 until 1882, and the second from 1884 until the day of his death. During the earlier period, he was engaged principally on city bridge work with the late John E. Cheney, who was then city bridge engineer. During this period several city bridges were built or reconstructed, notably, Dover Street, Meridian Street, Broadway and Chelsea bridges. In this period also the construction of the Boston Improved Sewerage System was in progress, and part of Mr. Tinkham's time was given to work in connection with the Boston Main Drainage System, particularly with the design and construction of the Calf Pasture Pumping Station.

By the fall of 1882 there had come a lull in the City's engineering work, such that Mr. Tinkham doubted whether his city position afforded him a future, and in November of that year he left the City's employ to become assistant engineer on the New York & New England Railroad, in charge of the design and erection of bridges for the double tracking of that road. His services for the New York & New England Railroad lasted until April, 1884, when his work on the road having been largely completed and prospects for engineering work for the City of Boston being brighter, he returned once more to the Boston city engineer's office, and for the following thirty-seven years, until the day he died, he was constantly in the City's service. Early in this second period of his work for the City, Mr. Tinkham was given the title of assistant engineer and principal draftsman of the Engineering Department. He became chief assistant to the bridge engineer, Mr. Cheney, and until the late '90's his work was largely that in charge of bridge designing. This period was one of considerable activity. Among the bridges built during this time were Allston, Beacon Street, Boylston Street, Brookline

Avenue and Cottage Farm bridges over the Boston & Albany Railroad; Byron Street Bridge, East Boston; Dover Street and L Street bridges in South Boston; the draw span of Neponset Bridge; and Harvard Bridge across the Charles River, which was built jointly by the cities of Boston and Cambridge under the direction of the Boston Engineering Department. At the time of its construction, Harvard Bridge was the largest bridge undertaking which had been carried out in this vicinity, the structure being some 2 200 ft. in length and having a width of 70 ft., except at the draw span, which is 50 ft. wide. Prior to its authorization, Mr. Cheney and Mr. Tinkham had jointly prepared preliminary estimates for a bridge of narrower width. When the authorization came, however, it was made on the basis of these estimates but prescribed the present larger width. This is illustrative of the difficulties which often confront the engineer, and it is greatly to the credit of the builders of this structure that, notwithstanding the inadequacy of the appropriation, the prescribed larger bridge was built within the sum allowed. By many, Harvard Bridge was looked upon as unnecessary. While it was under construction, the Boston Society of Civil Engineers, according to its custom, held an excursion to inspect the work, and one of the members of the Society inquired of Mr. Tinkham, who was in charge of the party, "Will anybody ever use this bridge? Will not Essex Street and West Boston Bridges take care of all the travel between Boston and Cambridge?" Considering that Harvard Bridge had become overtaxed long before Mr. Tinkham's death, this remark is indicative of lack of vision on the part of the member of the Society who made it.

In addition to his work on city bridges, Mr. Tinkham was engaged during the late '80's on further work of the Boston Improved Sewerage System and the Mystic Pumping Station, as well as upon studies for the elimination of grade crossings and other projected municipal improvements, in which work he was a forerunner of the modern city planner.

During the late '90's the engineering activities of the city were very largely increased. Several new bridges were undertaken, some of them, such as Charlestown and Cambridge bridges, being much larger structures than their predecessors. The

South Terminal Station, which was to unite the railroads on the southerly side of the city, was projected, involving much planning and construction by the City in a rearrangement of its streets and extensive constructions along the water front of Fort Point Channel. At the same time, Congress Street grade crossing on the South Boston flats, which had become a serious problem, was eliminated by the construction of Summer Street Extension across Fort Point Channel and over the South Boston flats, connecting with L Street Bridge at the Reserved Channel, South Boston. This was the largest grade-crossing elimination project which had been undertaken by the City, and Mr. Tinkham was largely responsible for the preliminary studies and for the final solution of the problem as embodied in the decree of the Grade Crossing Commission.

Up to this time, the bridge engineer, Mr. Cheney, had devoted his attention more largely to supervising construction in the field, while Mr. Tinkham, as his chief assistant, had devoted his time largely to work in the office. In the engineering activities of the late '90's, however, both Mr. Cheney and Mr. Tinkham found it necessary to devote practically all of their time to the supervision of construction in the field, Mr. Cheney assuming charge primarily of projects on the northerly side of the city, notably the Charlestown and Cambridge bridges over the Charles River, while Mr. Tinkham was given charge of the work in connection with the South Terminal Station, the Fort Point Channel improvements and the Summer Street Extension across Fort Point Channel and over the South Boston flats. Included in Mr. Tinkham's work was the building of Dorchester Avenue, in the location formerly occupied by the old wharves of Fort Point Channel, from Congress Street across Summer Street and alongside the entire South Terminal yard to Federal Street Bridge. This involved the construction of a sea wall half a mile in length, built under Mr. Tinkham's supervision, from his own carefully prepared designs and at remarkably low cost. Throughout the building of the South Terminal Station, Mr. Tinkham was engineer in direct charge of the City's work in connection with this project, and he was constantly in touch with representatives of the railroads concerned. He was instru-

mental in guiding this development and in the adoption of several construction features which he suggested. As an example of his foresight and his appreciation of traffic needs may be mentioned the "island" in Dewey Square, which was suggested and strongly insisted upon by him as necessary, not only to properly divide vehicular traffic into well-defined traffic streams but also to serve as a refuge bay for foot passengers crossing the square from the South Station to the junction of Federal and Summer streets. We know how traffic has increased in Dewey Square in the twenty-odd years since the South Terminal Station was built, and realize how much worse conditions would have been had not Mr. Tinkham had the wisdom to tenaciously adhere to his projected Dewey Square island.

For the last twenty-three years of his service for the City, Mr. Tinkham's work was largely that in charge of construction engineering, principally upon bridge construction work, but including also sea walls and retaining walls on land, difficult tide-water foundations, harbor shore protection, ferry improvements, wharves and other water-front structures. Some of the more notable projects with which he was connected, in addition to those already mentioned, are the building of the Northern Avenue and Sleeper Street improvement, from Atlantic Avenue in the City proper across Fort Point Channel and the South Boston flats, involving the construction of one of the most important of the City's tide-water bridges; grade-crossing elimination work, including the building of a number of new bridges over railroads; the rebuilding of Chelsea Bridge North over the Mystic River, including provision of the heaviest swing draw span in New England, spanning two navigation channels, each 125 ft. in width; the building of the new swing draw span of Broadway Bridge over Fort Point Channel; the rebuilding of Meridian Street and Chelsea Street bridges between East Boston and Chelsea, each with a swing draw span; the reconstruction of Malden Bridge between Charlestown and Everett in conjunction with the building of the Boston Elevated Railway Company's new Mystic River Bridge, and involving the construction of a large new bascule draw span; the rebuilding of Granite Avenue Bridge over the Neponset River, also with a bascule

draw span; the rebuilding or extensive reconstruction of many of the older tide-water bridges, such as Congress Street, L Street, Warren and Winthrop bridges; and the building or reconstruction of a long list of inland bridges — a list too long for present enumeration.

In 1911, the City Engineering Department, the Street Department and the Water Department of Boston were united into the present Public Works Department, and the new consolidated department was subdivided into three divisions, to one of which, the Bridge and Ferry Division, was assigned the building, operation and maintenance of the City's bridges and the East Boston Ferries, the elimination of grade crossings, and miscellaneous engineering work for the City which had formerly been handled by the city engineer's office. Mr. Tinkham was made construction engineer of the Bridge and Ferry Division, which position he held continuously until his death, and which was next in importance to that of the head of the division. Mr. Tinkham served as division engineer in charge of the Bridge and Ferry Division at various times in the absence of the division engineer, and was himself acting division engineer in 1914–1915, a position which brought him in contact with a variety of problems of administration in addition to those of an engineering nature.

Besides his work for the City, Mr. Tinkham was frequently retained by others in a consulting engineering capacity. For several years he was associated from time to time with Mr. Cheney in the latter's work as consulting bridge engineer for various railroads. Mr. Tinkham was also principal consultant upon many bridges built in different parts of New England, upon buildings and upon difficult foundation problems, as well as a consultant of the Metropolitan Water Board upon certain construction phases of the Metropolitan Water Works System.

Aside from his strictly professional work, Mr. Tinkham was of service to his profession in several allied directions in which his standing and experience as an engineer proved of distinct value.

His influence was largely felt in defining the underlying principles and establishing reasonable standards for the classi-

fication of engineers within the classified civil service of the state. The provisions of the Massachusetts Civil Service Law were extended in 1897 to include engineers in municipal employ, and in 1902 to include also engineers in the employ of the Commonwealth. Mr. Tinkham was appointed in 1897 one of the members of the first board of examiners for civil engineers in the classified service, a position which he held for more than fifteen years, until January, 1913. The other members of the original board of examiners were both members of this Society, — the late Henry Manley and Prof. Dwight Porter. As a member of this first board of examiners, Mr. Tinkham's influence was exerted in placing the engineering examinations upon a practicable and working basis.

Originally, civil service examinations were scholastic in their nature and the tendency was to estimate a man's fitness almost solely from his ability to pass a written test. Mr. Tinkham and the other members of his board saw from the beginning the futility of relying upon written examinations alone, and the importance of bringing in other means of ascertaining the fitness of the candidate to serve the city or the state. It was the duty of this first board, not only to determine the type and scope of examinations to be held and to decide the relative weights to be assigned to education, experience and demonstrated ability to do original constructive work as contrasted with mere ability to pass written examinations, but upon this board fell also the duty of framing the classifications by which the engineers then in the service, as well as those to be admitted later, would be graded.

It may be difficult for some of the younger members of this Society to realize the position of the engineer in governmental service prior to his inclusion within the classified service of the state, and to appreciate that no one had a greater influence than Mr. Tinkham in working out and establishing upon a rational basis the provisions of the civil service law as applied to the engineer in state and municipal employ.

Mr. Tinkham was of service to the profession at large through his active connection with many professional organizations. Aside from his membership and work in the Boston Society of Civil Engineers, which is treated at length by another

speaker, it may be noted that he became a member of the American Society of Civil Engineers in 1892 and was active in its affairs, serving twice as member and once as chairman of its nominating committee, and as a member of other committees, including a committee on the award of medals and prizes. For nearly thirty years he was a member of the New England Water Works Association, and for many years was a member also of the Massachusetts Highway Association.

A strong attachment for his *alma mater* was one of his outstanding characteristics, and all his life he was active in Technology alumni affairs. For many years he served as secretary of his class of '73, and it was this class which, in 1874, suggested the organization of the Technology Alumni Association. From 1882 to 1884, Mr. Tinkham was a member of the executive committee, and from 1884 to 1886 was vice-president of the Alumni Association. He represented his class on the Alumni Council from its organization in 1913 until his death. He was long an active member of the Association of Class Secretaries of the Institute. When the alumni were called upon, from time to time, for financial aid, his influence was actively exerted in the raising of funds for the support of the Institute.

A salient characteristic of Mr. Tinkham's life was his length of service, his sustained interest and his quiet, unassuming persistence in the many activities with which he was connected. His work at Boston City Hall — his chief vocation — lasted for a period of forty-five years. For forty-seven years he was a member of the Masonic fraternity, and another speaker testifies to his value and devotion to that body. He was long an attendant and for many years chairman of the standing committee of the First Church in Roxbury. His interest in Technology affairs was unflagging from the time of his graduation in 1873. His service on the board of examiners for engineers of the Massachusetts Civil Service Commission was long, devoted and untiring. His chief contribution to the engineering profession was his unparalleled service of more than thirty-six years as secretary of the Boston Society of Civil Engineers.

Mr. Tinkham was essentially a bridge engineer, but more than that he was a recognized authority on foundation problems

in general, and particularly upon constructions in tide-water under difficult and special conditions such as are encountered in Boston. His work of half a century covered a broad field, and he gained a fund of experience as well as a detailed knowledge of the City's engineering work, which made him invaluable not only in attacking new problems but in the care and maintenance of the City's engineering structures. At the time of his death, the highway bridges in Boston numbered 190, and nearly all of these were built or reconstructed — and some reconstructed a second time — during his connection with the City. The annual inspection of each of these structures, in which he shared at first and which he later directed, gave him an intimate acquaintance with the history, conditions and needs of each of them that no one else possessed.

The term "common-sense" engineer may be applied to Mr. Tinkham, a common-sense developed through his wide, varied and thorough experience. He learned just how work should be handled and carried out, and became a competent judge of good and proper work. He knew when a result was good enough for the purpose intended, and in consequence was not unreasonable in his decisions on contract work. He was broad enough to recognize and appreciate the contractor's difficulties and point of view, such that he was never over-exacting or finical in his relation with contractors, but at the same time he secured from the contractor faithful compliance with contract requirements and the degree of excellence of work needed in each particular case.

Mr. Tinkham worked harmoniously with, not against, the contractor. He was always ready to receive suggestions from the contractor, and was helpful in giving him the full benefit of his long construction experience, to the end that results might be produced by methods economical to the contractor and at the same time advantageous to the City. Many contractors, in bidding on construction work, take into account the personality of the engineer under whose charge the work is to be built. In the case of Mr. Tinkham, contractors knew that while under him a good quality of work was demanded, their interests would be secure against unreasonable decisions; in consequence, much

of the work done under Mr. Tinkham's charge was bid at low prices, of which the sea wall along Dorchester Avenue is an example. In this way Mr. Tinkham and his established reputation saved the City substantial sums over those which the City would have paid for work carried out under engineers of a different type.

Perhaps Mr. Tinkham's fundamental characteristics were unselfishness, companionability, a cheery good nature, and an absolute honesty, all of which were alike motive for and characteristic of everything he did; a sound common-sense which his long and intimate experience along many lines ripened into an insight of valuable depth and scope; and an unassuming, tireless activity always for, and usually with, others. Whatever he did, he did heartily. He concentrated his attention on performing each task thoroughly and well. His life was so filled with activity in different directions that there was scant time left for needed recreation, and his hours of idle leisure were rare indeed. His was truly a life of faithful and useful service.

A BROTHER MASON'S TRIBUTE.

By Hon. J. K. Berry.*

When you asked one from the Washington Lodge to speak of a brother Mason, and especially an engineer, it was natural for the thought to arise that Washington was as early and as renowned an engineer as any of which we find record in our history, and Washington was, when quite young, the Master of the Masonic Lodge at Alexandria. There, many of the portions of his regalia and many mementos of him in his Masonic life are now treasured in a very carefully prepared memorial building; and it was very natural that Everett Tinkham as we knew him should excel and be faithful both as a civil engineer or surveyor and as a Mason.

In 1873 the society of the Chi Phi established a chapter connected with Tech., and Mr. L. Jackson, afterwards a physician in Roxbury, invited and persuaded me to join their society; and after Everett passed away it occurred to me that probably he

* 14 Beacon Street, Boston, Mass.

joined at the same time I joined it. But I was in Harvard and didn't attend the meetings of the Chi Phi very much, so that I drifted away from that and I drifted away from him, and we didn't meet again as far as I know, until, I think it was in 1889, he joined some of our Roxbury bodies. He became a Mason in Taunton in 1874, when a little over twenty-two years old, and I have no record of him from that time until about 1888. Of course you know that in the meantime — 1879 — he was married, and you you can well understand that in those early years he was busy getting started in his profession, and then with his family, and didn't have time probably to devote to Masonic meetings and duties, although there is no question that he more than made up later for any time then lost.

Perhaps most of you know that a man joining the Masons obtains the first three degrees and is then eligible for further degrees in the Royal Arch Chapter, and that was the first step taken by Brother Tinkham in 1888. Then he became a member of the Mt. Vernon Royal Arch Chapter in Roxbury, and in the same year he passed on to the next Masonic body that he could enter, a few degrees further on, — the Roxbury Council of the Royal and Select Masters; and then nearly a year later he joined by affiliation our Washington Lodge in Roxbury, which was of the same order — the same number of degrees — as the Charles H. Titus Lodge in Taunton, in which he was raised.

From his joining the Chapter and the Council in 1888 his activities began, and we find him holding offices in both of these bodies at the same time, which required the memorizing of ritual with considerable variations; and, as you know he never belonged to anything unless he performed all the duties connected with it, he was very punctual and very faithful in his subordinate offices, and a great support to the officers above him, and was gradually promoted and added greatly to the efficiency of the Royal Arch Chapter and the Council.

Then, too, he started along in line in our Master Masons' Lodge, or what we might call the lodge of the first three degrees, but it took in those days some seven or eight years, — beginning near the bottom, say as a deacon or a steward, before one could arrive at the position of Worshipful Master. He passed through

all those steps,— or chairs, as they are called, — and in 1905 and 1906, I think it was, he was the Worshipful Master of Washington Lodge, and he had the remarkable distinction of being installed in that lodge by Most Worshipful Brother Baalis Sandford, of Taunton, the Grand Master of the Grand Lodge of Massachusetts, who out of personal friendship for Tinkham came up and installed him. This was the second instance in the history of Washington Lodge in which a Master was installed by a Grand Master. The first instance was when Ebenezer Seaver in 1796 was installed by Paul Revere, who then was Grand Master of the Grand Lodge.

I think it was about that time, too, that Everett Tinkham was active in what is considered the highest body of the York Rite Masonry, — namely, the Knights Templars, — and he proceeded through the Joseph Warren Commandery, the order in Roxbury being Washington Lodge, the Mt. Vernon Chapter, the Roxbury Council and then into Joseph Warren Commandery. He went through and became its Eminent Commander, and was, if I remember rightly, a District Deputy Grand High Priest in the Chapter and Grand Principal Conductor of the Work in the Grand Council of Royal and Select Masters. Those are upper bodies. And I am quite sure that he was a member of the Grand Commandery of Massachusetts and Rhode Island.

While he was Senior Warden in our Washington Lodge — about 1904 or 1905 — the Roxbury Temple on Warren Street was constructed, and the corner-stone was laid during his term of office. Later he became one of the Board of Trustees for that building, and president of the Association which owns and controls that building. Also he was a member of the Committee of Masonic Charity of the Grand Lodge. He was also for us a trustee of Washington Lodge, and trustee for other bodies in regard to their funds, both for building and for other purposes. Of course I don't need to say why. You who have known him for forty years know that he was just the kind of a man who, if willing to accept any trust, would faithfully serve.

A quiet man, you might say, in some respects. You might not suppose there was quite so much to him as there really was, until you came to live with him and work with him. He never offended you with his superior knowledge, but you always found

he knew something you didn't know which fitted in to help. On committee work he always helped with suggestions, and in that way made things a success.

I didn't have an early intimate acquaintance with him because I have never been able to give that close attention to Masonry that he gave. I am a Past Master of Washington Lodge, but my close attention was in the years 1887 and 1888, before, in fact, he had been a Past Master. I had been a Master before he joined the Lodge. But last fall and spring, I had the good fortune to be associated with him upon the committee to prepare the one hundred and twenty-fifth memorial of the establishing of the Lodge, and I had the pleasure of working with him evenings at his apartment, and with Mrs. Tinkham, and we had good times together. We reviewed the history of the Lodge for the first one hundred years, to make a synopsis of it to go with that of the last twenty-five years, and in that way had the sort of association with Brother Tinkham and with Mrs. Tinkham which really gets you right down to know "folks," as they say, — and they were sterling people. We were proud to have had him with us. It may have seemed perhaps that he gave more of his life to Masonry than he should have, but most of you know that Masonry is founded on the three great lights, the Holy Bible, the square and the compass, and while perhaps in giving a little more time than most men do, his work was along those lines, and also his actions with you and with others squared with all the implements and conditions that he had in Masonry. The different bodies with which he was connected in Masonry have been proud and have felt it a privilege to record our memorials to his worth and to let the family know that we felt grateful that they loaned us their husband and father to help.

He passed out, an instance of a faithful man who didn't have any press agent and probably few people heard of him during his lifetime, but when all is said and done there are probably few men who lived as complete a life as he, and ninety-nine per cent have not lived and cannot be expected to live as complete a life. A faithful man who did his duty to the City, Church, and to the fellow-members of his profession, to the public and to those of his fraternities. He did his duty every day.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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FEDERAL WATER-POWER LEGISLATION.

By Geo. C. Danforth,* Member Boston Society of Civil Engineers.

(Presented October 19, 1921.)

Considering the extent of our water resources, it is surprising that of our present power development exceeding 70 million horse power only 8 million, or about 10 per cent., is water. This failure to substitute a non-exhaustible resource for an exhaustible one is due partly to the fact that electric transmission was made available after many of our industries and railroads had been established on a coal-burning basis. A more important reason, however, is that water power, with an initial cost of development from two to five times that of steam, has been subject to many restrictions that steam power has not, and there is a greater financial risk in its development. In the matter of federal legislation, the government has consistently maintained a policy of restriction and control rather than of encouragement. The history of federal legislation dates from the Act of September 1, 1890 (26 Stat. 426), which provided that no bridge, breakwater, pier or abutment could be constructed beyond the harbor lines where established, and where they were not established such obstructions could not be made without the previous consent of the Secretary of War.

The Act of July 13, 1892 (27 Stat. 88), relates to the construction of wharves, piers and bridges over navigable waters,

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and requires the approval of the Secretary of War for an improvement or bridge. The Act of March 3, 1899 (30 Stat. 1121), required the consent of Congress for placing obstructions in navigable waters, and where such obstructions were in intrastate waters the Secretary of War and chief of engineers had to pass on the plans, notwithstanding authorization by the state legislature.

The next legislation was the so-called "General Dam Act" of June 21, 1906 (34 Stat. 386). This required the consent of Congress before a dam could be constructed in navigable waters, and the approval of the specifications, plans and location by the chief of engineers and Secretary of War. It also required the construction and operation of such locks and fishways as were deemed necessary. Two special acts passed under this Act in 1908 led to the vetoes of President Roosevelt, with the statement that no bills would be signed which did not provide a fixed charge and a limitation in time of the rights conferred. The Act of June 23, 1910 (36 Stat. 593), is amendatory of the preceding act and lays down many important rules and regulations for the construction of dams in navigable rivers.

Since 1910, Congress has been attempting to obtain legislation which would safeguard public interest without discouraging investment. The Ferris law which passed the House in 1914, providing for development on the public domain, failed of passage, as did a similar bill passed by the House in 1916; the Adamson bill, providing for construction of dams on navigable waters, which passed the House in 1914, and a like bill passed in 1916, had no better success. Each contained the provisions demanded by President Roosevelt, but were defeated in the Senate on the ground that Congress had no right to exact a charge for development of water power, and, in particular, for development on navigable waters.

The war, with its shortage of coal and oil, again drew attention to the need of legislation. A bill was submitted by President Wilson in December, 1917, but was killed in the last hours of the session by Senator LaFollette. The present bill (H.R. 3184), introduced by Representative Esch of Wisconsin, and passed by the House July 1, 1919, was passed by the Senate with several drastic amendments January 15, 1920. It went to conference

January 17, and was reported out April 30, with an even more drastic definition of navigable waters, in spite of certain opposition we were able to bring before the committee, including the efforts of Senator Lodge of Massachusetts. It was signed by the President June 10, 1920, and became law.

Something over eighteen months ago I read this law, in particular the definition of navigable waters as it was amended immediately before being sent to the conference committee, and took it on myself to say it was not what the East wanted. This was in the face of some opposition, for I was advised from Washington to leave it alone, and one of our Maine Senators said it did not interfere with our waters. Our efforts brought no result beyond writing a few speeches into the Congressional Record of May, 1920. New England, however, as an economic unit, is probably as interested in power as any section of the country of equal area, and it is not yet time for us to lose interest in legislation which affects us as much as this does. And all sections of the United States where power is privately owned have the same interest. Contrary to some expectations, I think we will find considerable resentment in the West at this further extension of bureaucratic control, — government in business. They have already had some experience with that control, and a prominent man in Colorado recently suggested that " now we are getting a dose of our own medicine, and it is possible that some of our business interests may wake up to its dangers."

A letter recently sent to the various state commissions has brought almost uniformly replies stating that they believed waters not actually navigable in fact should be exempt from federal control. New York State, which refused to help change the law before it was passed, is already taking this question of jurisdiction to the Supreme Court. North Carolina is preparing amendments in line with our proposals of eighteen months ago. The Water Power League of America, at a convention in New York on June 23 and 24, called because of dissatisfaction at the present Act, has created a committee of which the writer is a member, for the purpose of suggesting amendments; and it is a significant fact that the manufacturer who is perhaps most vitally

interested in power production and costs is adequately represented on that committee.

The Federal Power Commission is composed of the Secretaries of War, Interior and Agriculture. Mr. O. C. Merrill, formerly chief engineer of the Forest Service, was appointed executive secretary, and Lieut.-Col. William Kelly, Corps of Engineers, U. S. Army, was detailed as engineer officer. The Act provides that the work of the commission shall be carried on by personnel of the three departments.

The commission has power to issue licenses or preliminary permits for water-power developments on navigable streams (Sec. 4). Licenses are issued for not to exceed fifty years (Sec. 6). The right of eminent domain may be invoked for any power site (Sec. 21) and the plant may be taken over by the Government at the expiration of the license, at its net investment value (Sec. 14), or the license may be reissued to the same or another applicant. (Sec. 15).

If taken over by the Government or another licensee, going value or prospective revenue are not considered as net investment, and values allowed for water rights, rights of way, lands, etc., are not to be in excess of actual reasonable cost thereof at time of *acquisition* (Sec. 14).

Annual charges are to be paid to the United States, to cover cost of administering the Act, and excessive profits are to be expropriated (Sec. 10*e*). Adequate depreciation reserves are to be maintained (Sec. 10*c*), and a state commission, if there be such, or the Federal Commission, shall regulate rates and service of public utilities. There is also provided in Sec. 10*d* that after twenty years a percentage of earnings over and above a fair return shall go into an amortization fund, with the further interesting provision that this is to be applied in reducing the net investment.

Sec. 11*b* gives the right to compel any licensee to give, free of charge, land, structures and power which may be required for navigation purposes, and Sec. 12 provides for navigation structures included in the works when built.

Secs. 19 and 20 provide for regulation of rates and service.

Secs. 4 and 7 provide for certain coöperation with the states, and Secs. 9 and 27 for a non-interference with state laws.

Sec. 10*f* provides that head-water development costs can be charged to beneficiaries below. This would include extra as well as intrastate developments on interstate streams.

It may be well here to comment on the difference between waters which are navigable in fact and navigable waters of the United States as the term is legally defined.

The definition in the Act as finally passed is as follows:

" ' Navigable waters ' means those parts of streams or other bodies of water over which Congress has jurisdiction under its authority to regulate commerce with foreign nations and among the several states, and which either in their natural or improved condition notwithstanding interruptions between the navigable parts of such streams or waters by falls, shallows, or rapids compelling land carriage, are used or suitable for use for the transportation of persons or property in interstate or foreign commerce, including therein all such interrupting falls, shallows, or rapids; together with such other parts of streams as shall have been authorized by Congress for improvement by the United States or shall have been recommended to Congress for such improvement after investigation under its authority."

From many court decisions which I have available on the definition of navigable waters I quote the following:

" Rivers are navigable waters of the United States when they form in their ordinary condition by themselves a continued highway over which commerce is or may be carried on with other states or foreign countries in the customary modes in which such commerce is conducted by water." (The Daniel Ball; 10 Wall. 557 [1870].)

" Such waters entirely within the limits of a state are subject to the same control of the federal government as those extending through or reaching beyond the limits of a state." (101 Min. 197; 112 N. W. 395.)

" The construction of a dam in a river at a point where it is not navigable which so retards the flow of water as to affect the navigability at a point where it was navigable before is prohibited." (U. S. *v.* Rio Grande Dam & Irrigation Co., 174 U. S. 690 [1899].)

" Navigability in the sense of the law is not destroyed because the water course is interrupted by occasional natural obstructions or portages; nor need the navigation be open at all seasons of the year or at all stages of the water. . . . The Desplaines River has been out of use for a hundred years but . . . improvements in the

methods of water transportation . . . may restore the usefulness of this stream, and it is not difficult to believe that many other streams are in like condition. If they are to be abandoned it is for Congress, not the Courts, so to declare." (Economy Light & Power Co. *v.* U. S., Adv. Ops. 487, April, 1921, in the case of a river which had been used by traders and explorers previous to 1825.)

"In the absence of federal statute a state may by statute authorize the erection of a dam across a navigable river within its limits." (199 U. S. 473.)

"The unquestioned rule of the common law was that every riparian owner was entitled to the continued natural flow of the stream. . . . Although this power of changing the common-law rule as to streams within its dominion undoubtedly belongs to each state, yet two limitations must be recognized. First, that in the absence of specific authority from Congress a state cannot by its legislation destroy the right of the United States, as the owner of lands bordering on a stream, to the continued flow of its water; so far, at least, as may be necessary for the beneficial uses of the government property. Second, that it is limited by the superior power of the General Government to secure the uninterrupted navigability of all navigable streams within the limits of the United States. . . .

. . . It does not follow that the Courts would be justified in sustaining any proceeding by the Attorney-General to restrain any appropriation of the upper waters of a navigable stream. The question always is one of fact, whether such appropriation substantially interferes with the navigable capacity within the limits where navigation is a recognized fact. . . ." (U. S. *v.* Rio Grande Dam & Irrigation Co., 174 U. S. 690.)

"The servitude to the interests of navigation of privately owned lands forming the banks and bed of a stream is a natural servitude, confined to such streams as in their ordinary and natural condition are susceptible of valuable public use in navigation, and confined to the natural conditions of such streams.

"The power of the federal government to improve navigable streams in the interests of interstate and foreign commerce must be exercised when private property is taken, in subornation to the Fifth Amendment." (U. S. *v.* Cress, 243 U. S. 316 [1916].)

"The power of the Congress extends to the whole expanse of a navigable stream and is not dependent upon the depth or shallowness of the water.

"The judgment of Congress as to whether a construction in or over a river is or is not an obstacle or hindrance to navigation is an exercise of legislative power in respect to a matter wholly within its control and is conclusive." (U. S. *v.* Chandler Dunbar Co., 229 U. S. 269; 208 Fed. Rep. [1915].)

There would seem to be no question but that the Congress under the commerce clause of the Constitution has power over navigable waters for the purpose of conserving commerce among the several states and with foreign nations, and we assume that this control goes to the headwaters of our rivers. It is a different thing, however, to grant to Congress under the camouflage of the commerce clause of the Constitution the right to regulate all our streams for the power purposes or to give to a commission the right to destroy navigation as it may do under Section 12 of the Act. As a matter of fact, it is not possible to erect a headwater dam without improvement to navigation unless there is such actual diversion of the water as occurs where it is used for irrigation. The commission may refuse to permit a project which will improve navigation with the same facility with which it can destroy navigation in the actually navigable sections.

The original colonies were all sovereign states, and they surrender to the federal government only the right to control navigation in navigable waters. Other rights in their streams and waters were not surrendered, but reserved.

We have, however, to do with the Act itself until such time as the Courts may pass on its constitutionality.

Mr. M. O. Leighton, formerly chief hydrographer, U. S. Geological Survey, in testifying before the Congressional Water Power Committee in 1920, stated:

"By Section 9 of the Act of March 3, 1899, Congress asserted its control over all structures that affect the navigable waters of the United States. It is conceivable that under some conditions that control may extend to the uttermost sources of streams that are or *are declared to be* navigable in their lower reaches."

Recently the Judge Advocate-General of the Army, General Crowder, has been quoted as stating that the commission had jurisdiction over the "ultimate raindrop." And there is every indication that the commission is to take all the authority which the law gives it.

It seems that the remedy at the present time is to limit the jurisdiction of the commission by amending the law, and there is more reason than is generally supposed to believe that this effort to amend may be successful.

A possible form of amendment, which is of course only tentative, is to draw a line in the definition of navigable waters which will limit federal control to waters which are navigable in fact, waters in which commerce occurs and merchandise is carried in both directions in some kind of a vessel, to cut out absolutely that navigability which comes from throwing logs into one end of a river at high water and letting them run out the other. The following is suggested:

" Navigable waters " means those parts of streams or other bodies of water over which Congress has jurisdiction under its authority to regulate commerce with foreign nations and among the several states, which either in their natural or improved condition are in fact commercially navigable by boats or other vessels, but not above the lowest interruption by falls, shallows, rapids, or lawfully existing obstructions compelling land carriage, together with such other parts of streams as have been authorized by Congress for improvement by the United States for the carriage of freight or passengers, and all waters on the public lands of the United States.

This would eliminate one present trouble with the law, — that of not knowing whether a proposed development is under the jurisdiction of the commission or not, and having the alternative of either applying to the commission under Section 23 for a decision, which they will give at their convenience, or of going ahead without a license and being liable to the federal government for obstructing navigable waters of the United States and in addition guilty of a misdemeanor, to be punished as provided in Section 25 of the Act.

There is a provision in the United States Constitution, and in most state constitutions, usually to be found in the declaration of rights, that private property shall not be taken for public use without just compensation nor unless the public exigencies require it. Section 21 of this Act grants the right of eminent domain for obtaining sites licensed by the commission. Is this right of eminent domain to be applied regardless of whether the use to which this property is to be applied is a public or a private one? That question has been before the courts many times, and these court decisions have, I think, drawn a fairly distinct line between public and private use.

The chief engineer of the Division of Waterways of the Department of Public Works of Illinois has called attention to a possibility in connection with Section 10*f* two projects being licensed on a stream and one of the applicants having unlicensed plants on the same stream sufficient to justify headwater storage developments. Under this section licensee No. 1 might be required to pay one half the cost of the annual charges for the reservoir sites, including depreciation, whereas licensee No. 2 might own 90 per cent. of the power on the stream, unassessable either because it was constructed previous to the enactment of the law or was on a section of the stream not considered by the commission to be under their jurisdiction. Such benefits as flood control, improvements of sanitary and navigation conditions could not be assessed, although playing an important part in the creation of storage reservoirs.

Section 11*b* provides that the licensee shall give, free of charge, land, structures, power, etc., for navigation purposes. Would this in a dam already constructed without locks be taking of private property for public uses without compensation?

The only interest the United States should have in the waters of navigable streams is that it shall have necessary water to maintain or improve navigation. It has no right to require the licensee to furnish power to operate navigation structures, and these requirements might be extensive. It is suggested that the word "water" be substituted for "power" in this section.

In Section 10*c* there is a provision that the licensee shall maintain the project works in a condition of repair adequate for the purposes of navigation. In connection with the definition of project (Section 3) this might seem to imply that the licensee must maintain all navigation structures, which might include canals, locks, dams, embankments, dry docks, etc., placing on him an obligation which he is unable to foresee at the time of his application for a license. This provision should be changed so that the expense of maintenance should be borne by the Government.

I do not know just what the argument is for state rights. There was a war in regard to that, some years ago. I think it might reasonably be expected, however, that we could get along with less bureaucratic control of business from Washington.

Section 14 of the bill has an interest. Many of the states have state control of public utilities. The right of the Government to take over and operate projects permits them to operate public utilities in any state in competition with the companies already operating in that state. Have recent experiences been such as to create a belief that governmental operation of private business is efficient or desirable?

And I doubt if it would be possible to do conservative financing during the last ten years of the license period. The license should be renewable on the conditions of the original license unless notice were given ten years or more before the expiration of the license that the project is to be taken over by federal or state authorities.

It also might be asked whether the Government were in the best position to decide whether a proposed development were that best adapted to "a comprehensive scheme of improvement," as provided in Section 10*a*, or if this could not be better planned locally.

Section 10*d* provides that after twenty years there shall be maintained from the surplus, over and above a reasonable return on the "actual legitimate investment," an amortization fund which will be applied to reducing the net investment. It would also reduce the amount to be paid by the Government or a new licensee if taken over under Section 14, as well as any earning capacity based on that investment. One might even foresee a time when that net investment would be zero and it could be taken over without cost. In other words, the power commission is vested with such powers that it could take over, maintain and operate any project "covered in whole *or in part* by the license" at the expiration of the lease, with the provision that it shall pay the net investment of the licensee in the project plus reasonable severance damages to property not taken. This is in addition to the right to take over at any time by condemnation and payment of just compensation. Should the project prove unprofitable, the licensee must maintain it during the life of the license. It is difficult to believe that these provisions are constitutional, and it seems probable that they will tend to deflect capital from water-power investment.

It would seem also to be desirable that this section should provide that the earnings of those public utilities whose rates are controlled by state public service commissions should be assumed to be not in excess of "a reasonable rate of return."

Section 15 provides for an annual license in case the project is not taken over by the Government or the license reissued to the same or another concern. It is not reasonable for any corporation to work on an annual extension of lease, and it is believed that this period should be increased to at least five years.

Section 23 states the Act does not affect any permit or valid existing right of way heretofore granted. This can refer to federal permits only.

I am not in a position to comment in detail on the accounting system provided by the federal commission. A number of the items might be changed somewhat — in particular, Accounts 240 Depreciation Reserves and 301 Organization; — certain others should be eliminated as unnecessary or placed in a different section.

Many statements have been made to the effect that depreciation expenditures should go into the operating account and not into reserves which, estimated in advance, may far exceed the requirements of depreciation.

I am inclined to agree with a contention already made that a total elimination of the accounting system would be desirable, substituting therefor the filing of a report as made to the public utilities commissions of the various states.

A further objection is due to the amount of power given the commission in promulgating rules and regulations and in providing for coöperation with the states. Not only will a changing personnel bring changes in these rules and regulations but changes in the interpretation of the Act itself.

If this government bureau is to function properly it should be as far removed as possible from political influences and the inevitable results of control by a commission which goes out of office every four years and cannot but reflect the policies of the administration to which it belongs. And it will usually be the case that the duties of their respective departments will be so great that the commissioners will have little time to spare for

proper supervision. The commission should be abolished as a separate bureau and placed under one of the departments for administrative purposes, either the War Department or the proposed Department of Public Works, with personnel and policies which would be relatively permanent, or it should be freed entirely from departmental jurisdiction.

Sections 9*b* and 27 of the Act provide that it shall in no way interfere with state laws. The line drawn here is too vague to be satisfactory. While suitable state legislation might limit much harm that could be done, it would increase the existing restrictions rather than lessen them. The logical procedure is to limit the jurisdiction of the federal commission by amending the definition of navigable waters as applied to this Act. This amendment will not restrict development. It will not interfere with the public lands, and it will remove much of the privately owned power from federal control. Whatever removal of federal red-tape and restrictions can be effected must act as an incentive to development.

If the federal law cannot be amended, state legislation would probably be desirable, varying with the locality. New York has already passed a license law modeled somewhat after the federal law. Methods of accounting may be prescribed by state law, as also regulation of rates and service and expropriation of excess profits. It seems probable that the exercise of the right of eminent domain could also be controlled by the state, as there appears to be no reason why state legislation requiring certain methods in connection with condemnation proceedings would not be controlling.

The following court decision is of interest:

"But the federal Courts cannot take judicial notice that a stream is navigable because of an apparently irregular traffic in times of high water, employing Indian canoes and small steamboats and gasoline launches in face of a declaration by the legislature that such stream is not navigable." (33 Sup. Ct. 1024; 228 U. S. 708.)

At the present time there seems to be some relaxation of the strictness with which the jurisdiction of the commission may be asserted, and it is possible that the matter of jurisdiction over

certain rivers could be better settled now under the provisions of Section 23 than later if the parties interested should make application under that section for a ruling as to whether certain sites were under the jurisdiction of the commission. If the ruling were affirmative, the applicant would be no worse off than before. If negative, no future commission could reverse the ruling under the present law, and a valuable precedent would have been obtained in regard to other sites on the same river.

It may be of interest here to quote from the Congressional Record of June 24, 1921, statements of two eminent senators who have had much to do with the Act of 1920. Senator Jones of Washington, chairman of the committee on commerce, states:

"The commission has not acted as I had hoped it would act. It has acted as I feared it might. The time of Cabinet officers is so fully taken up with other things that they do not have the time to give the attention to this matter that it should have."

Senator Nelson of Minnesota stated:

"We finally succeeded in passing what I consider a most cumbersome and complicated general water-power bill. The law is so complicated that it has not been put in operation. I doubt whether the law will work satisfactorily or lead to that development of water power which we ought to have in this country. I am anxious to see the water powers of this country developed, but I fear that that law will act as a brake."

In closing I should like to say that the objection to certain details of this Act does not mean objection to the Act as a whole. It represents years of effort toward the framing of suitable legislation. The older laws left our water-power resources almost untouched, and we turned to coal and oil, which could be developed with fewer legal restrictions, with greater security to the investor, and in many cases at a lower cost. To-day not less than 85 per cent. of the power used in this country for domestic, public, industrial and railroad purposes is produced from coal and fuel oil, and while some individual steam-stations are highly efficient we have failed almost completely to realize the group efficiency of large systems and persisted in transporting steam power by rail as fuel, instead of over the wires as electrical energy. An average

load factor that might reasonably be as high as 50 per cent. remains at about 15 per cent. While power cannot be eliminated, the transportation of coal in bulk for power purposes should be. It seems as though the only way in which future power demands can be met is by the interconnection of tidewater coal stations and hydroelectric stations large enough to eliminate the waste of the isolated, low-efficiency plant. This federal legislation should be welcomed in so far as it is incentive to a development of an inexhaustible resource, conserving by just so much our exhaustible resources, coal and oil, and condemned for any interference it may place in the path of that development.

In the interest of that development it has seemed desirable to advance certain suggestions at the present time in regard to this law — in particular, amendments which limit the jurisdiction of the commission to waters that are commercially navigable by inserting a new definition of navigable waters; which place the commission in a position where its personnel and policies may be relatively permanent; and which make the accounting requirements reasonable. Other changes should be made, and the power of the commission to formulate such drastic regulations as those at present in force should be limited *in the law itself*. I feel, however, that if the definition of navigable waters can be suitably changed the greatest defect in the bill will have been remedied and lesser ones will have far less power for harm. If you want a governmental control of *commerce*, which is all the Government has a right to control, the definition must be changed. If you want control of *power*, the definition can stand as it is.

Vol. VIII DECEMBER, 1921 No. 10

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LABOR PROBLEMS OF TO-DAY.

By E. A. Johnson, Pres. Building Trades Council, and James Gauld, Carpenters District Council; with a Discussion by William Stanley Parker, Architect, and Morton C. Tuttle and Charles R. Gow, Members Boston Society of Civil Engineers.

(Presented November 16, 1921.)

E. A. Johnson.*

I had hoped that Mr. Parker, who represents the architects, the prime movers in the Building Congress, would be called upon to speak first, so that he might give you a brief synopsis of our activities and what we have tried to accomplish in the Building Congress. However, labor is first on the job and last to leave, so we will begin the job here.

The problems that confront the building industry is the subject for to-night. The problems that have confronted us in the past are history to all of us. Naturally we should be most concerned with what vitally confronts and interests us at the present time, but I shall have to go back a little, in order to arrive at my subject by steps, and I shall go back to 1919.

Conditions in the building industry at that time, between the Employers' Association and the units that composed the building trade unions, were of an individual nature. That is,

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the individual trades, crafts and callings of the local unions had individual agreements with their individual employers. The master plumbers had agreements with the Plumbers' union, the master steam fitters with the Steam Fitters' union, and so on down the list. In April, 1919, two trades struck for an increase in wages. These were followed by two or more trades in May. The other trades stayed on the job, though in some cases they had to knock off owing to the fact that the work was cut down. Then there was brought about a conference with all of the trades in the industry, by invitation of Mayor Peters. They met at City Hall, and nobody had in mind when we had our first meeting that we were going to enter into a new agreement in the industry. I know such a thought was far removed from my mind, and I have heard others say the same thing. Boston seems to have been the pioneer city to start movements of a new nature. We met on about twenty or twenty-one days, and the result of our meetings was what we now call, in communications and conferences, the June 27, 1919, agreement. That agreement was, as I say, a radical departure from the agreements that had been in force. It provided for two parties to the agreement, — the Building Trades Employers' Association and the United Building Trades Council. It provided for an arbitration board, and I can say that it eliminated the disputes which were previously a bugbear — troubles which were virtually union-made, where a man struck against his fellow-unionist on the job. We had the arbitration board take care of anything new not decided by the National Board or covered by it. There was only one dispute, during that agreement, which wasn't settled amicably. That happened on the tag end of the agreement, and possibly would have been rectified if there had been more time. Public hearings were held under the auspices of the State Board of Arbitration, and majorities of both groups considered that the agreement was satisfactory; although all felt that it could have been bettered, as can anything perfected to such a stage.

In October, 1919, as the agreement provided, notices were given by both sides that they were desirous of changes in any new agreement consummated. The Building Trades Council, as everybody knows, put in a request for $1.50 per hour. That

is history. I merely mention the fact in justice to the trade unions, that we did ask for the $1.50 an hour. Many would like to be getting it now. For this reason we asked for it. The press did not give any space as to why we asked for the $1.50 an hour.

In 1919 we had signed the new general agreement, under which the rate of pay was uniform and $1 an hour for all mechanics in the building industry. Simultaneously, in surrounding cities and towns wages of $1.05, $1.15, $1.20 an hour were paid. They virtually "rode on the wave." As far out as Newton, 5c. more than in Boston was received; in Lynn, 12½c. more; in New Bedford, 15c. more an hour; in Springfield, 25c. more as hour. Naturally, during the year and a half the agreement was in force, the mechanics in Boston asked, "Are we as good as those in other cities and towns? Doesn't it cost us as much to live?" And so we set our standard of request for wage increase from what we saw in surrounding places; and it must be remembered that in October of 1920 the cost of living, as shown by index figures in the report of the Commission on the Necessaries of Life, at the State House, reached the highest point in the history of the country, — I believe 220 points. That led us to consider it best to ask for $1.50, with the hope of possibly striking a point between $1 and $1.50. This request was not continued very long after the strike, or the lockout, as it may be termed, went into effect. The newspapers have never given the facts to the public in the form I have given them to you to-night. Only two or three months ago a newspaper printed an editorial, "What has become of the building trade strike?" and reiterated the $1.50 wage demand, as in their opinion we were still striving for the $1.50. So the public's mind has been bewildered.

At the present time there is no agreement existing in the city of Boston. Conditions are catch as catch can. Some say open shop prevails, and naturally our side claims we are holding our own. It is needless to go into details here to show you why and how we are holding our own. We have lived through a business depression, through economic conditions forced upon us during the last year, and have not lost members — to any greater extent than have other trades where similar industrial de-

pressions have occurred. Unions have come to stay, and even if "open shop" is seriously being put forward, as claimed by employers, nevertheless the building unions are still going to be with us.

We have endeavored to secure conferences with the Employers' Association, without results. That is, we have had one informal conference with executives of the Building Trades Employers' Association, and another through the invitation of the Boston Society of Architects, who felt that possibly if one of the five wheels to the coach, as it might be termed, intervened, it was possible something might result, and up to date the only result has been that the Employers' Association has made the provision that the Building Trades Council present a 100 per cent. front before they can enter into negotiations with it. In this connection I want to say that in 1919, when the new general agreement was entered into, there were two or three units connected with the Building Trades Council that would not enter into the new general agreement, so that this is a new demand or an innovation from the employers' side. The elevator constructors in 1919 were not party to the agreement but were part of the Building Trades Council. The sprinkler trades union was not party to the agreement but was part of the Council. Now the employers' request that we be 100 per cent. strong. Previously, owing to a strike, we lost one of our units in the building industry. We unseated them as a disciplinary measure, and they withdrew. It is our endeavor to enact disciplinary measures against any unit that refuses to live up to our rules. During the strike, or lockout, another unit in the building industry withdrew, also because of discipline. This time it withdrew because the majority wished arbitration and a small minority did not. I bring that out to show you that there is a conservative element in the building industry. We endeavor to do business, and police any negotiations with the thought that they shall be lived up too.

With the fact, however, that the two crafts are out of the Council it is impossible at this time to live up to the requirements of the employers, who say that before entering into negotiations they must meet us 100 per cent. strong. If the employers desire 100 per cent. representation, the unions also desire it. Possibly

conditions may have changed since the make-up of the Employers' Association, but they did lack a number of the crafts, — the stone cutters, tile layers, and others; and if the Employers' Association is going to block the wheels of progress by standing out for something they can't fulfill themselves, naturally we cannot get on a peace basis until we both agree to go in on equal ground.

We also question whether the general agreement is the best form. Many unions feel that it is dangerous to enter into a general form of agreement, and those of us who hold positions as officers of the unions have to allay these fears, if possible. Many feel there is no ground for it except for the purpose of getting into negotiations to find what the other fellow has to offer.

Many unions hold further to this particular point of view. In 1919 the agreement was an individual agreement existing between the individual trade and the individual employer, and when the new form in 1919 came into effect the individual forms of agreement that maintained the conference boards, etc., were addenda to the new general agreement. Now at present, as far as we can interpret the meaning of the new agreement of the Employers' Association, it is all-embracing. Many trades are jealous of their relations with their employers, and they feel there is a danger in entering a combine where a large group is going to determine wage questions, etc. They want that point cleared up. They want the relationship undisturbed. They want assurance that the relations they have had with their employers in the past will remain unchanged. It is the thought of many representatives of labor that until we can get into conference around the table nothing will come from letter-writing or anything else. This is just as true now as in 1919. Then we had no thought that we might get into a conference and come out with something entirely different. Men have been known to change their minds.

In general I want to say, getting away from the relations that exist at the present time, that labor's point of view has not been put before you, I believe, in the proper light. You depend on the newspapers, as we do to a greater or less extent. A week ago last night I had the pleasure of attending a meeting of the Boston Society of Architects, and after talking for over an

hour I excused myself, saying that I didn't realize I had talked so long. One man said, "I am glad you did, because we very rarely hear the point of view of labor." Possibly it is the same here, as I do not know how long it is since a labor man came before you. But it is my right and duty to put one thing before you to-night, and that is the fact that labor does not get the audiences that it should, and that contact is not established in a proper way. We allow separate groups to get together, and a fair example of this is the so-called Building Trades Investigation conducted recently by the Boston Chamber of Commerce. I quote a bulletin issued by the Chamber of Congress where, under the name of Messrs. Stewart and McConnel, it was stated that "the faults of labor are always apparent," and it went on to say that it mustn't be construed that this investigation was undertaken to try to lay stress on the faults of labor. The reason they didn't mention specifically the other parts of the industry was because they had not been able to get these groups together. I want to say that a month or a month and a half before this investigation, Mr. Penanski came to our office and we gave all the information and help we possibly could, and afterwards every one of our representatives went to that congress and gave information. We went of our own free will, and gave that information, and that is the position labor has always been in since I have been connected with the organization. Information did not have to be ferreted out. I wonder that, if a labor organization decided to hold an investigation, how many gentlemen representing the various industries would be present without being subpœnaed. I doubt whether any of the interests in Boston would have attended any labor hearing.

Through the Building Congress we have endeavored to establish points of contact; have endeavored to have the different groups in the industry get together, so we might learn from one another just where the shoe pinched the most. I have found some gentlemen in different parts of the industry who do not look with favor upon architects mingling with or endeavoring to bring together the employer and employee. I also believe they would look on with as much disfavor if the Boston Society of Civil Engineers assumed the same rôle. I have heard the opin-

ion expressed that the architect was an academic fellow, even an esthetic fellow, and shouldn't want to have anything to do with labor. That is a wrong conception. There isn't a unit in the industry that isn't directly concerned with the labor situation. If you are going to adopt the attitude of onlookers and stand on the side lines and leave it to the two groups to scrap it out, you must be satisfied and not complain afterwards.

During the congress, the investigation and the strike, or lock-out, editorials were printed criticizing rules; and the engineer, the investment broker and the owner criticized and asked, "Where do they get these rules? Who ever gave them the right to have these rules?" They criticized and wrote editorials, and where we would get 10c. worth of space they would get $5 000 worth. And still some of you assume the attitude that nobody but the employer or employee should be allowed to get together to adjust their differences. Now it should be realized that you are interested in labor, — and the architect and the engineer ought to be, and that you should endeavor to at least bring about a common understanding between the employer and the employee, because if not directly in contact with labor through the employers, still you are affected by the bad conditions that might be agreed upon between the employer and the employee, and are affected if no agreements enter into the industry. If the architect or engineer has supervision of a job and a strike occurs, the owner comes to him when the work is held up for any appreciable period, and then there are conferences in the architect's or the engineer's offices and a merely temporary settlement is patched up. And do you know, gentlemen, that through the fact that you have stood aloof and allowed temporary settlements to be made on your particular job, you are responsible for some of the conditions existing at the present time? You have been so anxious for temporary agreements to tide over a temporary condition. For instance, an engineer has an attachment on his engine and wants straight time on an eight-hour day. And then he wants two hours more. Well, you say, give it to him. And that becomes a law. So it is true that you are at least partly responsible for bringing about some of the rules that exist at the present time and of which you complain. I am going to digress again.

I am not a churchy fellow. There is no halo around my head. But there has been a lot said about the Golden Rule in industry, and in recent days I have served on committees with employers and have heard a lot about the Golden Rule in industry. I have seen ministers adopt the garb of the workingman in order to get his point of view, and while the papers have played it up spectacularly, all the ministers I have met *had* the point of view; all they needed was the contact with coöperative labor, and they got that contact and desired to continue that contact, and many business men have desired the same thing. The trouble is, we are all out of focus. We are all organized for our own particular end and neglect the man next to us. There are wheels within wheels, but no interrelation with one another. We are constantly slipping cogs, and will continue to do so until we all get together and do not allow two groups to stand on the side line, and "may the best man win." These results when summed up are going to affect you all just the same.

James Gauld.*

The task that is being put to labor to-night is a hard one, on account of the fact that there are so many evils connected with our industry, and they do not all rest with any one particular element of our industry. My colleague, Mr. Johnson, has covered a period where a great amount of harmony existed — a period of practically two years. Many of us here can look back over a period when conditions were not so harmonious. We all recollect the time when the builder, the owner and the architect had little or no knowledge as to when he would be in a position to deliver or to get his building for occupancy. In that day organized labor was looked upon as being responsible for that condition, and, in fact, as an unnecessary element in society. From that day it has been the aim and effort of the conservative element of labor to eliminate all those conditions. And we felt that we had accomplished something for the best interest of the industry in this city when we signed that last agreement. Much effort was required on the part of our rep-

* 30 Hanover Street, Boston, Mass.

resentatives to have their membership accept that agreement, for the simple reason that many of the features were looked upon with a measure of suspicion. One of the features that was looked upon with a great deal of suspicion was the termination of that agreement. We had to put it up to hundreds of hungry men as to the necessity of terminating that agreement on January 1, because we wanted to be a party to the stabilizing of our industry, by giving our contractors an opportunity to figure their work and to begin the season at a time when we felt we could adjust the conditions so that everybody would be satisfied. To-day we are confronted with an element in our organization that is over-suspicious, and says that our representatives did not tell the truth, in that their judgment was bad because they led us into a position where we were being taken advantage of by the association on account of climatic conditions. Consequently we are confronted with a membership that has no faith in the termination date from a stabilizing standpoint.

Our conservative element has endeavored, right straight along, to bring about a condition far from what it is to-day, and unless we can get the coöperation of societies similar to this and our associates in other sections of our industry, we are not going to be able much longer to hold the conservative element in power. Our organizations are fast becoming organizations of opportunists, and the present conditions are giving them ample opportunity to preach within the ranks doctrines far from idealism or Americanism. The various disinterested elements in our industry, as I see them, are, — First the engineers, with whom we have lost all direct contact. Then we have the architects, who are also far removed from direct contact with labor, and they are the fellows who lead us into a maze with their meager specifications, and create, in many instances, jurisdictional disputes. Then we have the contractor who has lost the old-fashioned contact with his employee, — the man who now knows his employee by number; which makes it necessary to deal with labor through direct contact with professional representatives. Labor in many instances is assailed for things for which they are not directly responsible. We are looked upon in many instances as an element composed mostly of destructionists, for the simple reason

that seldom do you pause to get into direct contact with the representatives of the labor-union element and find out what it is all about. The previous speaker cited the fact that we policed the agreement. That is an absolute fact, and how many of you here that know we deviated from the usual procedure to the extent of proposing to censure to the extent of striking against one of the parties to the agreement that did not live up to it? We seldom get an opportunity to lay those things before the interested parties, and it is my hope that we may get opportunity here to-night to analyze each section of our industry and find out of just what we are accused. Seldom do we get an opportunity like this, and that is why we should avail ourselves of it. Probably few of you realize that we are in a peculiar position just now. Our membership, which is cosmopolitan to a great extent, is leaning towards other channels where it feels it may get relief from the present conditions. We find that we have the contractor to-day that is taking full advantage of the situation and of the supply of labor. He is at present paying just as little as he possibly can. That may be one way of solving the situation in relation to the cost of building or a bigger profit for himself, but I want to tell you candidly that that action is going to bring about this result: The men will neither listen to reason or anything else when the opportunity arrives. When they see that the time is ripe they are going to be in a position to demand, and they are going to demand, their full share. Now that is a condition that we can remedy if the various elements of this industry will get interested in it and will get busy to the extent of helping to solve our troubles. We find that another great evil during the times of peace is the division of authority. In other words, we find that when grievances arise on the work, where we feel that injustice has been done, we are passed from one element to another, none of them willing to assume the responsibility for the situation. Sometimes we feel that the architect could eliminate considerable of that trouble. He allows the owner to reserve the right to get figures on his subcontracts, and he will invariably attempt to mix up union and non-union men. That immediately means trouble. Those elements will not mix with any degree of satisfaction, either to the contractor or to the

laborer or to the owner. Consequently we feel that in some acceptable society, possibly this new-found Congress, we will be able to get together and try to have these various grievances eliminated. Some of us feel that we could get away from lots of grievances if we could get away from the old form of contract. Now we feel that labor is going to subscribe to any of these things if we can be assured our rights will be protected. We also feel that we should no longer be allowed to break our connections with our employers. We feel to-day, regarding this trouble of many weeks, that the entire thing could have been averted had some other element stepped in. Consequently, we feel that if at any other future time any element sees that the Employers' Association and the organized bodies of labor are at a breaking point, it is then that element's duty to step in and patch up our troubles and keep us at work. The last strike has demonstrated that to us within the ranks of labor, and probably the Association will see it in the same light.

Now, Mr. Chairman, there has been another feature that I feel we should all get busy on. As self-respecting American citizens we should take at all times the opportunity of curbing any other form of aggregation of workmen other than the recognized and acceptable form of the American Federation of Trade Unions. There is gradually, but surely, coming to the surface an element of radicalism, and it will not be the element that I represent that will be affected mostly by its control. It will be the parties that will have to deal with this radical branch of our citizenship. It may not have been forcibly brought to your attention, gentlemen, but there is no organization in the building industry that is free from radicalism to-day, and the conditions that are going on are fostering that spirit to the extent that we feel before very long that we, the buffer element within our organizations, will be no more. You will have an element that will not agree to anything. The time is now to stay it. They are already flouting before the officials that there are write-ups in every official building journal and editorials in the press portraying that the time for building has arrived, and that in the very near future our industry will be back to normal condition. Consequently that element is already advocating

that we should deal with no association, and I am hoping you will use your influence to bring about a healthier condition by immediately starting negotiations for a new agreement.

Now I feel that coming here and advocating our cause would be of such a lengthy nature that I think it would be far better that we should hear of the misdeeds of labor and be given an opportunity to defend our action to the best of our ability. Consequently I am unprepared to go into any great detail to present anything other than what I have just now said.

All I want to do is to ask this Society to interest themselves in our industry and see if they can't get it back to a healthy condition, because, just as sure as I am standing here to-night, so long as we "dillydally," conditions as I portray to you will exist.

DISCUSSION.

William Stanley Parker.*

I am very glad to be here. This platform is as ample as the platform printed in your notice. I was glad to find that it was not a political platform, but one that one could not only get on but could stand on for the purpose of stating anything one might want to say.

The topic, "Labor Problems of the Industry," might be equally truly stated if the first word were eliminated; if it read just "Problems of the Industry," because labor problems really touch and are a fundamental part of all the problems, not only of labor but of all groups that represent the industry. I suppose in one word we might say that to-day the present problem of labor, or the general problem, is work. If we could get some work we might solve some of our problems, and if we got too much we might create some others, because one of the problems of the industry to-day is, where is the labor? Why is it that in an open-shop city like Los Angeles the plasterers have a union wage, I think, of $8 a day, and are getting $12 and $15, and in New York the same story, in England the same story? Where are the plasterers? Why haven't new ones come into the field, and is it

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the problem of the contractor and the labor group to solve? Are they the only two elements in the labor industry interested to find out why plasterers are not coming into the field, and how to remedy that condition? Personally, if I as an architect can't get my building built, I am going to do anything that will help the situation. I consider that difficulty is my business. At present I know very little about it, because I haven't come into contact with the men in the building industry. I do feel that in the past there has been too little coöperation among the various elements in the industry. For the reason of that lack of contact I think I have failed to give really any particular attention to one of the problems in the industry, and that is, periodic or seasonal unemployment; which seems to be one of the very definite problems not only in the building industry but of a great many other industries. Apparently it occurs in the shoe industry, as in the building industry, though perhaps there it is more a question of style than actual weather; but seasonable lack of employment appears to be just as great there, if not greater than in the building industry.

We made that the first subject of our Building Congress discussion, feeling that there was a common point of interest we might well look into, and without any very great expense or delay in finding the facts. We found, however, that the facts, as you engineers would consider them facts, didn't exist. We could find no records in the industry here regarding seasonal unemployment. The only thing we could do was to take the general impressions of labor and their general experience in regard to the seasons when their men were all busy and seasons when they had a great many on the settees who wanted a position. From them we got that general information as a first step, giving the months when all the men were employed in the industry and the months when they were not generally employed, and the percentage of unemployment that existed in the different trades. From this information we worked out rough curves which varied according to the trade and its relation to the industry. I want to go into the question of just what that proportion of unemployment is. The percentage of unemployment in the various elements of the industry varies from 25 to 75 per cent. of the men.

We find, for instance, the painters and decorators, masons, and hoisting and portable engineers — the three most significant — drop to 25 per cent. employed for three or four months. So far as we can make out, they have no other form of income, except what they get out of this industry. We are told the reason is they do not know just when they will get a job. It is always "to-morrow." They prefer to work at their regular industry rather than take up something else. They never develop anything else because they do not know, for instance, from say December 31 to April 31, whether they are going to get a position or not. They have practically no support, therefore, except from their own industry. What is the reaction of that fact on the wages, for instance? Consider the painters and decorators — the 2 700 men in the union ranks. They have an average, apparently, of something like 60 per cent. employment during the year. When you turn your dollar or 90c., or even the $1.50 asked for at a certain period into 60 per cent. yearly employment, you find out what the average man gets in yearly income, and the man is paid by the week but he lives by the year.

These facts were brought out strikingly in New York, where the same problems exist as here only multiplied ten times. As a matter of fact, they are just about one to ten in the case of the painters. About 25 000 were employed for five months and the rest of the year about 5 000. The rest were only partly employed. Now that is our problem, — as much ours as that of labor. We can't get good work from men employed 50 per cent. of the time. We can't get either good work or good citizenship out of that sort of man. Isn't that our problem as well as the problem of the industry? As much as it is labor's problem? So, it seems to me, on all of these problems we cannot but agree, as soon as we get into a study of the problems, — the contractor's problem, the subcontractor's problem, etc., — with good old Sir Roger de Coverley, "that much could be said on both sides." It was that thought that led to the formation of the Building Congress. The trouble, it seems to me, is, as was stated the other day at a meeting in Indianapolis, by the editor of the *Journal of the American Institute of Architects*, who was called on to speak at the final meeting there. He said he felt that one of the greatest prob-

lems of to-day was cleaning up the channels of information; that the means of getting at the facts of the case were so clogged by interest — some special interest or expedient or policy — that one doesn't know really what to believe. You would read in this or that paper diametrically opposed statements. At the time of the last strike here there appeared diametrically opposed statements from the employers and labor. I venture to say that none of us could really form our own opinion accurately, because none of us really knew the facts. And so, in order to clear away the obstructions that have been interposed between the various elements in the industry, that have prevented their getting into close touch and finding out the other fellow's point of view, we formed this Building Congress.

It was started by the American Institute of Architects, which called a meeting at Atlantic City a little over a year ago. At this meeting there were present a number of architects, engineers, contractors, subcontractors, representatives of labor, and material men. This meeting was unanimous in believing that the formation of a Building Congress as proposed was a wise move, as no other existing organization embraced all elements of the industry.

The national group had some preliminary meetings, and developed its scheme of organization. They felt, however, that the problems were primarily subjects for local solutions, and that the national body could not be reasonably effective until a group of local bodies had become active.

Local groups were started almost simultaneously about a year ago in New York and Boston. We called a preliminary meeting here, which believed that the movement should be developed, and at this meeting there were present representatives of all the eight groups in the industry, as follows: Architects, engineers, contractors, subcontractors, material producers, material distributors, labor, and building investment. A first organizing committee of eight was appointed, one from each of these groups.

After preliminary discussion, this committee decided to increase its membership to twenty-four, three from each group, and this enlarged membership has been active ever since in developing the work of the Congress.

Your representatives in the Congress are, — Colonel Gow, Colonel Gunby and Mr. Fay. Perhaps I should say "Colonel Fay," for nowadays, scratch an engineer and one is apt to find a colonel.

We took up, first, the question of seasonal unemployment, as I have reported, and it is indeed a pretty hard nut to crack. At present we are engaged in discussing the functional relations of the various elements in the industry. I don't know whether this will lead to disarming or arming. We are certainly very frank. We are laying our cards face up on the table. We are not talking about ourselves but about the other fellows in the industry, giving our experiences of the difficulties we have run up against in dealing with the other elements, and endeavoring to find out why we function badly, and how we may correct the difficulties that we find so often exist. We are trying to find out why the different elements act as they do, and to learn their point of view through this close contact and frank discussion.

I hope you will all think kindly of this movement. Those of us who are trying to start it may not be able to put it through, but we are hoping to do so, and some time we may be in a position to come to you to back us up, and we hope then we shall have your help.

Morton C. Tuttle.*

The rise of the publicity adviser is a new thing in American advertising. Some of our big corporations, some of our important individuals, and occasionally an entire industry, has decided that it needs advice regarding the education of the public away from a critical and toward an appreciative attitude. It has been recognized that the appreciation of the public increases as a clearer understanding grows about certain features of the firm, the individual or the industry. One or two people have developed great ability in this process of establishing good understanding between such misunderstood individuals and the American public. I suspect that one of these very able individuals is now at work re-establishing the friendly relations between the

* Aberthaw Construction Company, 27 School Street, Boston, Mass.

public and the anthracite coal industry, because recently some very good advertisements have appeared, explaining, one at a time, various features of the coal situation that are not commonly borne in mind. I believe that during the past years some one has worked very intelligently with the Standard Oil Company's publicity, and as a result Standard Oil does not suffer the criticism that it inherited from past time.

These publicity advisers are far more than writers of advertisements. As a matter of fact, few of them touch the actual detail of the advertising, nor do they write the articles. They are paid for making a study of the activities, personalities and general relationships of the firms, individuals or industries, and from these studies determine what facts, properly told, will react favorably upon their client. Nor do they confine themselves alone to publicity matters, but advise as to changes of methods, new relationships and new methods of operation which will create favorable rather than unfavorable comment.

I believe that such advisers must have not only a clear, broad understanding of the principles and relationships involved, but must have the moral courage to reject many statements which would react favorably, simply because these statements are not strictly true, or because a statement which is strictly true is too involved to be readily understood.

In approaching a new problem, one of these publicity advisers must eagerly wish to make many statements which later he finds impossible to make. It must be interesting to approach a new problem, knowing that if certain things can be said broadly enough and pointedly enough, great good will result to the client.

In the past few days I have been following a whimsical line of thought — perhaps not practical — which has interested me: Supposing this audience were called in as publicity advisers for the American labor unions. What would we wish to say that would give the public a cordial appreciation of the American labor union? How many of the things that we wish to say could be said of the unions as they are conducted to-day? It may be interesting to think over some of the high points.

First, we should wish to explain that the organization of the American labor unions was a simple one. We should wish to say

this because any badly set up organization always works evil. There must not be complicated relationships, dual authorities or unknown limitations of authorities, because these will lead to misunderstanding, if not to evil. We should wish to say that the authorities of officers are clearly defined, and their agreements made within these authorities are binding and permanent.

Such a clean-cut organization would preclude the possibility of misapprehension as to the powers and authorities of any one except a responsible officer. The lines of organization would be so clearly marked that there would be no possiblilty that at the lines of a metropolitan district, at a state line, or through a tangling of authority between craft and federation, the agreement of such officer could act in any way except as the party of the second part expected it to act.

With such clean-cut organization, we should want to say that the unions were ready to make written agreements which could be filed in some public office, which agreements would be backed like any other business agreement, not only by the reputation, but by the property, of the organization making such agreements. If we were setting about to fully explain in a friendly way the advantages of complete unionization of industry, we should explain that every representative of the union who approached an employer was prepared to furnish that employer with a statement showing completely the authority with which he acted. Such credentials would set forth his exact authority and would show the organization which he represented. Where such action depended upon the acceptance of local unions, it would show the endorsement procedure required even down to the certified statement of the votes taken in ratifying such agreements.

We would make it clear that there would be no expectation that an employer would be asked to accept an agreement not properly endorsed by the organization and individuals whom it was proposed to bind. It would be fully explained that if it became necessary to force agreements upon an unwilling employer, the unions would still follow the practice of furnishing certificates fully setting forth authorities by which they acted.

In such presentation to the public, we would wish to say

that all the terms in discussing the merits of unionism were clearly understood by the public in exactly the same way that they are understood by the unions. It would be desirable to define clearly such terms as "right to organize," "fair conditions," "representatives of their own choosing" and "willingness to work with unorganized labor."

It would be most helpful in such publicity if we could make it clear that the employer is the aggressor in to-day's labor situation. We could not go back into old time, because it would not be frank to discuss conditions of the past when we are dealing with the present. It would be helpful to make it clear that labor must be and is in need of defense from unscrupulous and aggressive employers. We must explain to the public that the existence of any body of men not strictly unionized is a menace to the safety of labor. That is, we must explain that the ideal situation will result from complete unionism, and from this point we must explain to the public that such a complete control or monopoly of labor will not be used in the ugly way in which monopolies of food, of money or of commodity have been commonly used. We will have to make it clear that the situation that develops from this ideal condition of complete unionization of labor will be generously and intelligently used in a broad-minded care of the public good, and that it cannot and must not be used solely for class advantage.

If we were a publicity adviser, working with this problem of presenting the advantages of unionism to the American people, it would be very helpful to state that the partial realization of the ideal has aroused the enthusiasm of employees, employers and the public. The employees have found that the complete control of labor in given localities and in given industries has worked not only to an increase of their incomes and leisure, but to an increase of their self-respect and to better and pleasanter relations with their employers. Such relationships have not only strengthened the bonds of sympathy between the employer and the employee in the industries, thus increasing the pleasure of the every-day relationship between the workman and his employer, but have also increased the self-respect and the general value as a citizen of the majority of the members of the unions.

We should want to say that as the strength of the unions has increased in any locality or in any industry, more and more they have devoted their energies to the establishing of agreeable relationships in the shops in which their men work day by day.

We would wish to say that as the attention of the unions can be diverted from the aggression of the employers, their attention has been increasingly given to the problems of social betterment, to the improvement of the working conditions of the women, to the proper handling of the problem of the child worker, to the subject of proper educational facilities, and to the general broadening of the horizon of their members.

With a clear understanding of the truth of these statements, the American public would understand that here was a great engine for industrial and national improvement, — an organization whose works were so good and whose aims were so broad and so high that any intelligent, patriotic employer should eagerly wish to accept their theories, not only because the interest of his employees would be safeguarded, their minds stimulated and their workmanship improved, but that as a result of these things his own relations with his men would be improved, his problems simplified, and as a result his interests safeguarded. With such belief spread through this country, there would be an overwhelming demand for the unionization of industry. Officers of unions would have time to devote themselves to constructive thinking about the social and economical improvement of their membership, as they would be freed from defending their men from the aggression of the employer.

I have tried to indicate in this talk a few of the things that we would wish to say if we were publicity advisers for the American unions. When we came to study the actual conditions and the actual methods employed, it might develop that some of these statements would not be available for publicity purposes. If it were desirable to make any of these statements, then the wish to make them might indicate the paths which our clients would follow in leading the American public to a full appreciation of their efforts.

CHAS. R. GOW.*

Most of you are aware that for a considerable portion of the past year I have been somewhat offensively active in attacking many of the aims and policies of organized labor. My criticisms, however, have been directed not in a personal sense against any individual or any group of men, but rather against the philosophy which they have chosen to adopt. I have had in my experience probably a better opportunity for contact with men prominent in the labor movement than possibly a great majority of you gentlemen have had, and I am glad to say that in that connection I have met many men who are equally as likable fellows as are Mr. Johnson and Mr. Gauld, who I know must have impressed you most favorably. On the other hand, I have met occasional hard-boiled characters among the labor men; but I could undoubtedly find their counterparts among the employing class in the industry, and I doubt if the proportion would vary materially. I have no intention of going into personalities, and no desire to stigmatize any particular group in the industry, but wish only to express frankly and earnestly a criticism fundamental to the whole situation. It is an economic one. It is this:

Engineers have recognized always that a man cannot lift himself up by his boot straps over a 6-ft. wall. You cannot make water run up hill of its own volition, nor can you have your cake and eat it too. This, it seems to me, organized labor has attempted to do, and this I criticize. Theirs is a philosophy fundamentally unsound, and until it is corrected they cannot expect to rehabilitate the industry in its rightful position where everybody can work with them.

Getting down to the question of wages, it seems to me, if any man will look at the matter fairly and squarely he will realize that a wage, no matter how small or how large, is of value only to the extent that it may be exchanged for personal service or commodities. If you cannot so exchange it, it is of no value and its amount is a matter of no consequence. The value of every commodity is represented by the aggregate value of all service which

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has gone into its production, manufacture and distribution. It is the aggregate value of all the service which has been expended upon it, regardless of whether that service has been over- or under-valued in its several divisions. Therefore it stands to reason that the total value of all the commodities produced in a given period is the total value which has been placed upon the personal services in the form of income. It may be clearly demonstrated, therefore, that wages are merely a convenient medium by which one man can exchange his services for the services of somebody else. If you or I receive a definite amount of money in our envelopes on Saturday night, it is simply a convenient medium by which we can purchase the services of somebody who has made shoes or raised foodstuffs, clothing, or something else which we need and which we cannot produce ourselves. It ought to be perfectly clear, it seems to me, that if everybody, regardless of the nature of their services, had their wages raised say 100 per cent. all at the same time, the result obviously would be that the value of all commodities would be automatically doubled coincident with this doubling of pay. In that case none of us would be any better off financially, since all of us could buy only one half of what we bought before for the same amount. An additional burden would fall, however, upon the man temporarily unemployed, the man with his money invested at a fixed percentage, the widows and orphans, — all such people living on a fixed income, or upon their savings, would be only one half as well off as they previously were. That would be the net result.

Conversely, suppose everybody's income was to be decreased 50 per cent. simultaneously. Everybody would receive one half as much as previously and the cost of commodities would automatically be reduced in the same proportion. Now, when these gentlemen speak of their demands for the 50 per cent. increase which was presented to their employers some months ago, I wonder if they have given any consideration to the economic effect in case it had been granted. I noticed in a paper I was reading to-day a report from the National Bureau of Economic Research, which stated that the proportion of labor to profit is placed at approximately 80 and 20 per cent. In other words, 80 per cent. on the average represents what is paid out in labor

wage, and 20 per cent. the proportion distributed in the form of profits among the several individuals who serve in the rôle of employers. Now, assume that conditions warranted a demand on the part of labor that their wages should be increased 50 per cent., — in other words, from $1 to $1.50 per hour. That would mean that if no additional increase was taken in added profit the cost of commodities affected by this labor would increase 40 per cent. The laborer would receive 50 per cent. and would apparently be 10 per cent. better off with this wage than before. But, of course, as soon as such a cost adjustment takes place the engineer, the architect, the doctor, the lawyer, the public official, the store clerk, the employers of those men — and everybody else who had to live — would realize that their standard of living had been reduced, because the cost of commodities which they needed had gone up 40 per cent. and their incomes had not been increased, so that they would immediately demand a similar advance. That is just what happened during the past few years. Before the war ended such a large proportion of our people had secured an increase of 100 per cent. or more in their income that the cost of living also increased 100 per cent. This didn't hold true in some specific cases. Some received a greater increase and some less. If the situation had continued long enough an approximate level would have been struck, and that is what is bound to happen whenever you attempt to meet that sort of condition by an increase in incomes. You cannot beat the fundamental law of supply and demand. I know that is an objectionable phrase to a great many people, but it is an economic truth that we cannot escape.

Now, the fact of the matter is that the immediate trouble to-day with the construction industry seems to be that we cannot get down to economic cost levels. That is the reason we are not progressing, that we are not able to build buildings. We cannot build them cheaply enough to permit the man who wants to build to do so. He is the one in the final analysis who determines whether he is able to build or not, and it is not a situation where he can be compelled to build at an arbitrary price, but rather one of building at his price or not at all. The owner will not build, and should not do so, unless he can obtain a satisfactory return

on his investment. If he will not build and we have no work, what difference does it make what wages these men may get on paper? Suppose you grant $1.50 an hour and there is little or no work. It might well be that a wage of 50c. an hour would in a year bring a greater total income, — a yearly income, — with a large volume of work than would the $1.50 with only a scant amount of work available, because of the prohibitive cost.

That is the situation which confronts all of us. It confronts the employer as well as the laborer. At the present time, if I am any judge, and I can speak from personal experience, — the employer to a large extent is no longer concerned with how much profit he is going to make, but with how little loss he can escape. In other words, he has been forced to deflate because there is no device or method by which he can fix his cost and effect an agreement with the owner or builder which compels him to comply with it. The material man has taken his reduction. Steel rods purchased a year ago for $105 a ton were quoted recently at $45. Lumber prices have dropped from $75 to as low as $35 a thousand feet. Cement purchased in 1920 at $6 or $7 a barrel has now been stabilized at $2.60; and so on down the list, with a few exceptions. There are, I regret to say, a few lines of industry whose leaders apparently still cling to the same hope which actuates the labor unions, that somehow, by standing pat, prices can artificially be maintained at their former high level. My criticisms are directed equally against both classes.

It is extremely improbable that high prices could be retained even if we all desired such a result. For a great many years we fought vigorously against the rising cost of living. We elected men to office who promised to put a stop to it; we had meetings, elections and committees; we passed resolutions and enacted new laws, and still the cost of living kept on rising just the same. That was not a new experience. It happened before at least twice in the history of this country, since records have been kept, and those records have been available for our information for many years. We had a period of high commodity costs in 1812, at the time of the war with England, — the Napoleonic Wars. Prices mounted to substantially the same peak as in recent years. Then there was a long period of falling prices, falling labor costs,

falling rents and falling costs for everything which covered a period of thirty years, followed by rising prices for twenty years. The new generation began spending the money that the old conservative and thrifty generation had saved, and we had a period of extravagance and waste, which appeared to produce prosperity because of the large amount of money expended, and this process culminated in another peak of high prices at the time of the Civil War, almost identical with the former peak. Then came a reversal of the cycle, and the lowest level of prices ever recorded was reached in 1896 and 1897, or thereabouts. Another twenty-year period of rising prices culminated in this terrible situation we have just passed through.

It is useless to attempt to stem the tide of economic events by ignoring them or by burying our heads in the sand or passing resolutions or organizing against them, unless we remove the fundamental causes. A study of these recurring cycles shows clearly that when we have general waste and extravagance in our affairs we produce what appears to be prosperity. The greater volume of buying naturally produces a demand for commodities, and this demand calls for more labor. Demand for labor brings higher wages, higher profits, and higher costs; but, when we reach a certain point in the inflation process, economic limitations bring the movement to a stop, and we turn the corner only to follow the downward route again. My sole criticism of organized labor is that it attempts to disregard and prevent these fundamental laws.

It is a fact that the general trend of wages has, generally speaking, been upward for one hundred and twenty years. There have been violent fluctuations, but the average line will show a gradual upward tendency. There was a substantial rise and subsequent fall of wages during and after the Civil War period, and a less pronounced similar movement at other periods. Nevertheless the net movement has been upward. The one thing which has made this result possible has been the very thing which organized labor has always strenuously fought against, — the introduction of labor-saving devices. Any agency which increases production releases a certain number of men from that industry, who are gradually absorbed in other productive lines,

the net result being that a greater total of commodities is produced which gives to each individual a larger per capita share. For instance, if we were a group cast away on an island it would require perhaps 25 or 30 of us to secure the daily food supply for the entire party. Now, suppose some one of us who was exceptionally clever in woodcraft should devise an ingenious method by which we could secure double the amount of food which had previously been possible. The result would be that we could immediately dispense with one half of the men employed for this purpose and distribute their services among the remaining groups who would be occupied with other tasks. It is easy to see, under these conditions, that each member of the entire party would then receive just as good a living as before, but would not have to work quite as hard because there would be more individuals to share in the work.

It is difficult for the individual to understand the application of this principle to our complex type of civilization, but that is what actually happens. The introduction of the cotton gin brought the cost of cotton cloth down to one tenth of its former price, and this was the equivalent of a raise in wages for every one who used cotton goods.

The thing which has disturbed me more than anything else in the attitude of labor organizations has been the general tendency to impose absurd rules requiring the services of two or more men to do one man's work. This practice must inevitably result in increasing the cost of the commodity, whatever it may be. It is absolutely unsound in principle, and can only serve to react against the best interests of the entire community, labor included.

There is no simple and attractive cure for our present business and social troubles. Only by a rigid adherence to sound economic principles can we re-establish normal conditions, and this is bound to be accomplished only when we are willing to accept lower wages, lower profits and lower costs of commodities. We may attempt to apply artificial expedients to prevent the operation of natural laws, but it is inevitable that they will ultimately prevail, and our efforts in opposition can only result in prolonging present unsatisfactory conditions.

Mr. Johnson. — The last speaker* brought out a particular point I have heard brought out before, and I should like to answer him. He says labor unions prohibit one mechanic from doing another mechanic's work. We have some mechanics that follow other trades, — bricklayers do plastering, carpenters do it also, and there are other examples. But they must live up to the particular craft union that they are working under at the time.

If any of you are in possession of a copy of the chart compiled by the Building Congress you will find that we took that particular phase of the industry, and we found that it is not very acceptable to the employer. We found many employers not only figure their work on the estimate of what work can be accomplished, but that they figure it on the particular men they are going to put on that work. They know when figuring that particular work that Jim, John or Tom are to be on that job, and they are going to have him on that job.

We have to have a standing army on hand, and we never know what demand is going to be placed on it, and we always have to have men on demand of the employers, and if we are going to allow them to be shunted about on different kinds of work we must have some guaranty. We have four 'phones in headquarters, and in normal times it takes two men to answer these 'phones. One day we will have a call for fifty mechanics, and the next for one hundred and fifty. No one knows on how many days of the year he is going to be called upon, and we can't have men doing different kinds of work.

* Mr. E. S. Larned.

MEMOIR OF DECEASED MEMBER.

ROY C. AIKEN.*

Roy Cobb Aiken was born at Park Hill, Westmoreland, N. H., April 5, 1872, and died at the Waltham Hospital, June 24, 1921. He was educated in the public schools, followed later by a course in the evening schools and also a course at Bryant & Stratton Commercial School.

During the greater portion of his life he was engaged upon various public works in the Metropolitan District.

In 1894 he began work as rodman and transitman in the city engineer's office in Newton; from 1896 to 1898 was with the city of Cambridge on the construction of the Hobbs Brook water supply; in 1899, with the Harbor and Land Commission on the state line survey; in 1900, with the Boston Elevated Railway Company; from 1900 to 1902, with the Metropolitan Sewerage Commission; from 1902 to 1908, with the Boston Transit Commission; from 1908 to 1910, with the Charles River Basin Commission; in 1918 and 1919, at the Army Base, South Boston.

He was also employed as clerk of works and superintendent of construction by various architects and engineers, among whom were Blackall, Clapp & Whittemore and Aspinwall & Lincoln.

He married Gertrude Geraldine Garside, who survives him, together with four children, — three sons and a daughter.

Mr. Aiken became a member of the Boston Society of Civil Engineers in November, 1900. He was a frequent attendant at the meetings and enjoyed the opportunity of mingling with his associates engaged in similar work. He was a member of the Congregational Church and of the Monitor Lodge of Masons in Waltham.

Mr. Aiken was a man of a quiet and retiring nature, diligent and conscientious in all his work, and always ready to subordinate his own convenience to the requirements of his employment.

* Memoir prepared by John L. Howard.

Vol. VIII JANUARY, 1921 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Water-Power Development in New England." By H. K. Barrows.

"The St. Lawrence River Project." By Henry I. Harriman.

Memoir of deceased member.

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MINUTES OF MEETINGS.

BOSTON, December 17, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.55 o'clock by the President, Frank A. Barbour.

The record of the last meeting was read and approved. The Secretary reported, for the Board of Government, the election of the following to membership in the grades named:

As members — Henry C. Archibald, William A. Brown, M. Warren Cowles, Silas Stanley Kent.

As a junior — Walter C. Richards.

The President announced the death of the following members of the Society: George S. Rice, who died December 7, 1920, and Edward A. Freeman, who died December 13, 1920.

By vote the President was requested to appoint committees to prepare memoirs, and the following appointments have been made: on memoir of Mr. Rice, Messrs. Desmond FitzGerald, Alfred D. Flinn, and E. W. Howe; and on memoir of Mr. Freeman, Prof. C. M. Spofford.

Mr. R. A. Hale, for himself and Mr. James R. Baldwin, the committee appointed to prepare a memoir of Loammi F. Baldwin, submitted their report, which was accepted and ordered printed in the JOURNAL of the Society.

Mr. E. W. Howe presented the following resolutions concerning a proposed amendment of the Federal Water Power Act, and moved their adoption, which was seconded by Mr. Desmond FitzGerald:

"*Whereas*, the Federal Water Power Act passed by the 66th Congress authorizes the Water Power Commission to issue licenses for 'constructing, operating and maintaining dams, water conduits, reservoirs, power houses, transmission lines or other project works' in the National Parks and Monuments on exactly the same basis as in the National Forests and other public lands, and

Whereas, irrigation interests are seeking rights for storage reservoirs in the National Parks and are strongly urging the passage of the *precedent-making* Falls River Basin Bill, otherwise known as the Smith Bill (H. R. 12416), which has passed the Senate and is pending before the House of Representatives with a favorable report, and which grants easements for 'irrigation plants, dams, reservoirs, canals, ditches, pipes and pipe lines' in Yellowstone National Park; now, therefore,

Be it resolved, that the Boston Society of Civil Engineers endorses the attempt to secure an amendment of the Act creating the Federal Power Commission which shall exempt the National Parks and Monuments from its provisions; and also

Be it resolved, that the Society specifically opposes the Falls River Basin Bill (H. R. 12466), believing it to be establishing a dangerous precedent and doing irreparable injury to a large section of one of the most important of our National Parks; and, furthermore,

Be it resolved, that the Board of Government of the Society be authorized and directed to coöperate with other organizations working for the protection of the National Parks and Monuments."

After a short discussion by Messrs. Howe, FitzGerald, W. H. Sawyer, S. H. Thorndike, J. E. L. Monaghan, and the

defeat of a motion to lay on the table until further information could be obtained, the resolutions were adopted. The President announced that the resolutions would now be sent out to a letter-ballot, as required by the Constitution of the Society.

The President stated that a communication had been received from the Joint Conference Committee inviting the Society to become a member of the Federated American Engineering Societies, and that it had been referred to a committee to consider the advisability of joining. The committee submitted its report to-day, but the question is so important that he felt that more time should be given to its consideration than is possible at this meeting; he therefore suggested that a special adjourned meeting be held for the purpose. It was accordingly voted that when the meeting adjourns it be to Wednesday evening, December 29, 1920.

At 8.15 o'clock the literary exercises of the evening were taken up. The President explained that this was the first of a series of three joint meetings held by the Boston Section of the American Society of Mechanical Engineers, the Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers. At these meetings hydroelectric development and transmission will be the subjects for discussion.

This, the first meeting of the series, he stated, is held under the auspices of this Society, and he introduced the first speaker of the evening, Prof. Harold K. Barrows, who read a paper entitled "Water-Power Development in New England." The paper was illustrated by a large number of lantern-slide diagrams.

The second speaker was Mr. Henry I. Harriman, president of the New England Power Company, who spoke of the so-called St. Lawrence Project.

At 10.15 the meeting was adjourned. The attendance of members of the three organizations and their guests was fully five hundred.

S. E. Tinkham, *Secretary.*

Boston, December 29, 1920. — The adjourned meeting of the Society was called to order in the Society rooms by the President, Mr. Frank A. Barbour, at 7.55 o'clock P.M.

There were 35 members present. The President said that this adjournment of the regular December meeting had been made to give sufficient time for the discussion of the important question of the Society affiliating with the Federated American Engineering Societies.

He stated that a communication had been received from the joint Conference Committee, inviting the Society to become a charter member of the Federation, and that the Board of Government had referred the invitation to a committee for consideration. He then called on Mr. Weston, chairman of that committee, who presented the following report:

BOSTON, December 16, 1920.

THE BOARD OF GOVERNMENT,
BOSTON SOCIETY OF CIVIL ENGINEERS,
TREMONT TEMPLE, BOSTON, MASS.

Gentlemen, — Your committee, appointed to consider the advisability of the Society joining the Federated American Engineering Societies, has given careful consideration to the subject, including the hearing of an address by Mr. Herbert Hoover, the newly elected president of the federation, and reports as follows:

We believe that there exists a useful field for an organization whose object is "to further the public welfare wherever technical knowledge and engineering experience are involved, and to consider and act upon matters of common concern to the engineering and allied professions."

We believe the new association can become an instrument for informing the public regarding the functions and abilities of engineers, and the part they may play in the life of the world. It may also act as an instrument for expressing the common thought of the engineering profession.

We believe that the success of the new association will depend upon the character of its management; if unselfish, wise and conservative, the advantages to the member societies and the profession will be great; if selfish, foolish and radical, the federation will easily degenerate into a political machine of which the component parts may feel ashamed. However, the present management represents the best in the profession, and we believe that it is incumbent upon the Boston Society of Civil Engineers to join the federation if it be able to do so. It may do so with safety because the constitution of the Federated American Engineering Societies provides that any member society may withdraw on either June 30 or December 31 of any year by giving three months' notice, and by discharging its financial obligations.

The objections to joining are largely financial, but are so serious that

they must be overcome before the Society can accept membership in the new organization.

The budget for the current year shows that the expenses of our Society will exceed materially its anticipated current income, the estimated overdraft being substantially equivalent to the entire income accruing from the permanent fund this year.

If the Society should decide to join the Federated Societies, it would be necessary for it to raise, this year, approximately $850 additional. The only methods available for doing this are, apparently, —

(*a*) The securing of additional members in sufficient number to overcome the present deficit by an amount equal to the dues of the Federated Engineering Societies.

(*b*) Abandonment of some of the present activities of the Society.

(*c*) Raising the dues of the Society by constitutional amendment.

Your committee feels that the abandonment or serious curtailment of any of the present activities of the Society would interfere with the efforts the Society is now making to promote the professional and social welfare of its members, particularly its younger members, to an extent which could not be compensated by any advantages likely to be derived from membership in the Federated Societies; that there is no prospect of securing additional members sufficient to accomplish the result stated under (*a*); that the Board would not be justified in advising membership in the Association unless it could feel sure that decreased membership and a reduction in the rate of growth would not follow a raise in the dues by constitutional amendment which is the only method for overcoming the financial obstacle which your committee can suggest.

In view of the above consideration, your committee is unanimous in recommending that our Society should not accept the invitation of the chairman of the Joint Conference Committee to join the Federated American Engineering Societies unless it is feasible to overcome the financial objection by adding one dollar per year to the dues, and in recommending that a questionnaire be sent out to ascertain the willingness of the members to bear the additional financial burden which membership in the new association would impose. Furthermore, it is the opinion of your committee that in judging the results of the canvass, and when taking further action, especial consideration should be given to the minority, some of whom might feel unable to continue their membership in the Society if the dues were increased.

Very respectfully,

(Signed) Robert Spurr Weston.
(Signed) Charles M. Spofford.
(Signed) Frank O. Whitney.

At the conclusion of the reading of the report the President made a statement in reference to the finances of the Society for the present year and for the coming year.

Past President Charles T. Main then read a statement which he had prepared, on the origin, formation and objects of the Federated American Engineering Societies and the American Engineering Council, from which the following abstract has been made.

In 1918 the four founder societies, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining and Metallurgical Engineers, each appointed committees to consider the internal affairs of the society and the external relations to the profession in general and to the public.

These four committees combined to consider external relations, and was known as a Joint Development Committee and was later known as the Joint Conference Committee. After careful deliberation and a vast amount of work, the Joint Conference Committee presented its report the latter part of the year 1919. This report was approved in principle by the four founder societies.

On January 23, 1920, a joint meeting was held of the Joint Conference Committee, the councils of the four societies, the American Society for Testing Materials, Trustees of United Engineering Society and Members of the Engineering Council, and it was resolved that the Conference approves in principle the report, and requests the Joint Committee to call, without delay, a conference of representatives of national, local, state and regional engineering organizations to bring into existence the comprehensive organization proposed.

An organization conference was held in Washington, June 3 and 4, 1920, at which were present representatives from more than seventy-five engineering societies, with an aggregate membership of more than 125 000.

At this meeting, "*The Federated Engineering Societies*" was organized.

The object of the federation is "to further the public welfare wherever technical knowledge and engineering experience

are involved, and to consider and act upon matters of common concern to engineering and allied technical professions."

Its *membership* is to "consist of national, local, state and regional engineering and allied technical organizations and affiliations."

The *management* is vested in a body known as American Engineering Council and its Executive Board.

The *representatives in the Council* are selected from the various member societies, each society being entitled to one representative for a membership of one hundred to one thousand and one additional for each additional thousand or fraction thereof.

The *Council* shall hold at least one meeting a year.

The *Executive Board* consists of thirty members, of whom six shall be the officers elected by the Council and twenty-four selected from the member societies. It shall meet at least bi-monthly, and will conduct the business of the federation.

This board is similar to the recent Engineering Council, and will carry forward the work of Council.

Funds to carry on the work will be contributed by the member societies, the national societies contributing $1.50 and the local societies $1.00 annually per member.

The membership of any constituent organization may be *terminated* on June 30 or December 31 of any year, by giving three months' notice.

Past President Metcalf followed with an urgent plea that the Society join the federation even if it were deemed best to meet the financial obligations by the curtailment of some of the Society's activities rather than by increasing the annual dues.

A very general discussion followed, in which Messrs. Fitz-Gerald, Larned, Bryant, Sanborn, Fales, Gunby and others took part. It was finally voted that it is the sense of the meeting that the Boston Society of Civil Engineers should join the federation, and that it is also the sense of the meeting that this should be done without increasing the annual dues.

It was also voted that the Board of Government be requested to arrange for the proper presentation of the matter at the next meeting of the Society.

At the request of some of the members, Past President FitzGerald gave further information relative to the Federal Water Power Act and the Society's resolutions now before the members for a letter-ballot. At 9.30 Vice-President R. S. Weston, who was in the chair, declared the meeting adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[January 15, 1921.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates, which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BURRAGE, HENRY THOMPSON, Cambridge, Mass. (Age 63, b. Roxbury, Mass.) Started in as rodman for Barbour and Hodges in 1874 and worked for them two years. In 1876 was employed by the city engineer of Cambridge, and has been in this office ever since, and at present is assistant engineer. Refers to Henry S. Adams, L. M. Hastings, G. Franklin Hooker and Charles A. Mason.

CRONIN, WILLIAM HENRY, Cambridge, Mass. (Age 47, b. Boston, Mass.) Graduate of Phillips Grammar and Boston Evening High schools. Employed continuously for the past twenty-five years with the Engineering Department of the Metropolitan Park Commission. At present is assistant

engineer in the Engineering Department, Metropolitan District, Park Division, and work consists of surveys and plans for acquirement and conveyance of land, lines and grades, estimates and inspection on roadways, bridges, seawalls, culverts, etc. In 1906 was construction engineer, and 1907 construction inspector in U. S. Reclamation Service; 1909 C.E. Intercoastal Waterways; 1918 highway engineer, Bureau Public Roads, and chief of survey party, Construction Division of the Army. Refers to David A. Ambrose, Geo. W. Dakin, Carl S. Drake, D. J. Lynch, J. E. L. Monaghan and James E. Stone.

Haggerty, Thomas Joseph, Boston, Mass. (Age 29, b. Boston, Mass.) Graduate of mechanical engineering in 1915, structural engineering in 1917, at Lowell Institute. Started engineering work in June, 1912, with Herbert S. Kimball, chemical plant and mill engineer, as detail draftsman for one year, draftsman three years and designing four years on wood, steel and reinforced concrete structures. Has been employed by Mr. Kimball, 75 State Street, Boston, for the past eight years. Refers to David A. Ambrose, William A. Brown, Walter B. Douglass and Herbert S. Kimball.

Mirabelli, Eugene, Dorchester, Mass. (Age 23, b. Boston, Mass.) Received S.B. in civil engineering at Mass. Institute of Technology, 1918, and certificate in naval architecture and ship construction in December, 1918, at M. I. T. Was with McClintic-Marshall Co., at Pittsburg, Pa., from January, 1919, to September, 1920, on structural steel work, including two months in fabricating shop; nine months in drafting room making shop drawings; six months in the field, and four months estimating and designing. In October, 1920, was appointed instructor in bridge design at Mass. Institute of Technology. Refers to Prof. J. B. Babcock, Prof. H. L. Bowman, H. M. Chadwick, J. C. Moses, A. P. Porter and Prof. C. M. Spofford.

Murphy, John Joseph, Boston, Mass. (Age 28, b. Boston, Mass.) Graduated from Mechanic Arts High School, Boston, 1911; from Lowell Institute "Buildings Course" in 1917. September, 1911, to June, 1912, with Fuller Whitney Survey Corp., 15 Court Square, Boston, as rodman and transitman; June, 1912, to the present with the City of Boston, Park Department, as rodman, transitman and assistant engineer, and in 1919 was appointed engineer of the Park Department, where he is at the present time. Refers to John E. Carty, William H. Ellis, Jr., Charles E. Houghton and Edward T. Murphy.

Nowell, Frank, J, West Roxbury, Mass. (Age 57, b. Kennebunkport, Me.) Began engineering about 1882, under Ed. Lydston, then on survey for beeline railroad, Boston to New York. Also with Frederick Law Olmsted, Brookline; Waring, Chapman and Farquhar, sanitary engineers, Newport, R. I.; also with City of Boston, Stony Brook Improvement, under Sidney Smith. In December, 1889, was appointed assistant engineer under Howard A. Carson, Metropolitan Sewerage Commission, and has worked ever since for the State Highway Commission, Metropolitan Park Commission, and now with the Metropolitan District Commission, Parks Division. Refers to David A. Ambrose, George W. Dakin, Edgar S. Dorr, Carl S. Drake, A. M. Lovis and John E. L. Monaghan.

Shaw, Percy A., Manchester, N. H. (Age 36, b. Athol, So. Dak.) Graduated from Brown University in 1908, with B.S. in civil engineering. Spent four summers on engineering work; 1908–1909 was at Lancaster, Pa., with F. H. Shaw, cons. municipal engineer; 1909–1912, railway engineer in charge of branch office for F. H. Shaw, on design and construction of bridges, sewerage and water works; 1912–1917, principal assistant engineer with F. H. Shaw, in charge of office, designing and supervising construction of water supply, sewerage works, bridges, etc.; 1917 to date with L. H. Shattuck, Inc., designing and constructing industrial buildings. Hydroelectric plants, dams, etc. Refers to H. K. Barrows, Arthur C. Eaton, C. H. Pierce, G. G. Shedd, R. S. Weston.

Shea, Joseph Thomas, Cambridge, Mass. (Age 23. b. Cambridge, Mass.) Educated at Rindge Technical School, 1913–1917; George Washington University, 1918–1919. At present attending evening school at Mass. Institute of Technology. At present, draftsman in office of principal assistant engineer, Boston & Albany R. R. Refers to L. G. Brackett, T. P. Perkins, A. S. Tuttle, J. J. Rourke.

Smith, Merritt Parker, Arlington, Mass. (Age 23, b. North Scituate, R. I.) Graduated from Mass. Institute of Technology with class of 1919. Was junior highway engineer with the state of Illinois from June, 1919, to Sept., 1920. Appointed instructor at Technology, Sept., 1920. Refers to Prof. J. B. Babcock, Prof. C. B. Breed, Prof. Dwight Porter and Prof. C. M. Spofford.

Watson, George Newell, Watertown, Mass. (Age 19, b. Manchester, Mass.) Since 1918 has been employed by the Town of Watertown, Engineering Department, general office and field work under Wilbur F. Learned and Forrest J. Maynard. Is attending Northeastern College, evening school of engineering, taking a three-year course. Is at present working in the engineering department, Watertown, Mass. Refers to W. E. Eberhard, Wilbur F. Learned, Forrest J. Maynard and H. A. Maynard.

LIST OF MEMBERS.

ADDITIONS.

Kent, Silas Stanley ..... 66 Broadway, Lowell, Mass.
Murphy, Daniel A. ..... 17 Kenburma Rd., Dorchester, Mass.
Patterson, Herbert L. ..... 23 Playstead Rd., Boston 25, Mass.
Richard, Walter C. ..... 390 Front St., Weymouth, Mass.

CHANGES OF ADDRESS.

Abbott, Robinson ..... Tufts College, Mass.
Bissell, H. ..... 705 No. Orange Grove, Pasadena, Calif.
Bresth, Alexander ..... Box 655, Gainesville, Fla.

Bryant, William A. ..... 155 Mason Ter., Brookline 47, Mass.
Clark, William A. ..... 305 Cutler Bldg., Rochester, N. Y.
Coffin, S. P. ..... 12 Remington St., Cambridge, Mass.
Eberhard, Walter C. ..... 133 Waverley St., Waverley, Mass.
Ferguson, John N. ..... Room 420, State House, Boston, Mass.
Green, Howard W. ..... International Health Board, Central Aquirre, P. R.
Hart, Frank S. ..... 2 Warren Rd., Framingham, Mass.
Harty, J. J. ..... Care Monks & Johnson, 99 Chauncy St., Boston, Mass.
Hurd, Stephen P. ..... Room 304, 4500 Euclid Ave., Cleveland, Ohio
Kitfield, Edward H. ..... Swampscott, Mass.
Morphy, Luis G. ..... Chief Engineer, Rutland Railroad, Rutland, Vt.
Price, Herman S.,
U. S. Geol. Survey, Montana National Bank Bldg., Helena, Mont.
Spear, Walter E. ..... Merrick, N. Y.
Starr, J. A. ..... 28 Playstead Rd., Dorchester, Mass.
Stearns, Ralph H. ..... P. O. Box 1129, Boston, Mass.
Thorpe, L. D. ..... Room 1129, Old South Bldg., Boston, Mass.

DEATH.

Blake, Edmund M. ..... January 12, 1921

LIBRARY NOTES.

Book Review.

Handbook of Building Construction: By Hool and Johnson, Consulting Engineers. First edition. First impression, New York, McGraw-Hill Book Co. Leather, 6 x 9 in.; 2 vols., pp. 1 474, figures and tables.

Reviewed by J. R. Worcester.

The title of this book of nearly 1 500 pages, 6 in. by 9 in., in two volumes, is somewhat misleading if one is looking for a condensed collection of data. If, however, he is seeking a comprehensive compilation touching every phase of building construction, this work will be likely to please him. The authors have had the assistance of forty-six specialists, each of whom has written one or more sections. While this method of securing expert knowledge in a great variety of fields has its manifest advantages, it inevitably disturbs the consistent, consecutive arrangement which the work of one head would have developed.

It seems to a casual reader as if it had involved needless repetition, not of words or data, but of lines of thought upon similar subjects, treated in different chapters when they might have been combined.

An awkward feature of the book is the necessity of using both volumes together, the table of contents for both being in the first and the index for both in the second. If the matter could have been completely divided so that each volume would have been self-contained, it would generally be necessary to refer to only one to obtain the desired information. Then, again, one misses a systematic grouping of subjects which would enable him to turn, without studying a table of contents, to the approximate place in the book where he might find what he wants. This difficulty will, of course, grow less with greater familiarity with the book.

It would be hard to think of any branch of building construction which is not covered more or less fully. Some features are given in most explicit detail, with illustrative examples, though others are treated somewhat superficially. In places, the reader is apparently assumed to be a beginner, who requires enlightenment on most elementary points; while in others the subject is treated on a plane altogether above the comprehension of a novice. It would no doubt be impossible to cover the whole field as thoroughly as some parts are covered, and even upon the subjects less thoroughly covered there will always be found information which will be useful to many.

Much data needed by structural engineers is given in tabular form, which has never been before collected in so small a space, if, indeed, it has ever been published. This compilation of data is enough, even without the descriptive matter, to give the book a great value. Moreover, the excellence of the typography — barring a few errors which will no doubt be corrected in later editions — and the clearness of the illustrations, leave nothing to be desired, and increase the satisfaction with which the work will be consulted.

Recent Additions to the Library.

U. S. Government Reports.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. Bulletin 686-Y.

Mortality Statistics, 1919.

Municipal Reports.

Cambridge, Mass. Report of Water Department for year ending March 31, 1919.

New Bedford, Mass. Report of Engineering Department 1919.

Newton, Mass. Report of Engineering Department. 1919.

Miscellaneous.

Handbook of Building Construction. Hool & Johnson. 2 vols.

Life in a Large Manufacturing Plant. Charles M. Ripley.

Vol. VIII FEBRUARY, 1921 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Rat Extermination and Proofing with Relation to Prevention of Plague." By L. L. Williams.

Memoir of deceased member.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, January 26, 1921. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Frank A. Barbour.

There were present 120 members and visitors.

By vote the reading of the record of the last meeting was dispensed with.

The Secretary reported for the Board of Government the election to membership of the following candidates in the grades named:

Members — Messrs. William H. Chase, Theodore P. Clark, Walter L. Cronin, Francis A. Garvin, Parker Holbrook, Anselmo Krigger, Charles A. Leary, Franklin E. Leland, Francis R. Mac-

Leay, George H. Newcomb, J. Francis Travers, Jr., David J. White, Walter A. Woods and Frank V. Wright.

Juniors — Messrs. James F. Harvey, Scott Keith and Albert G. Martin.

The Secretary also reported for the Board its recommendation that the following vote be passed:

Voted: That the entire income of the Permanent Fund for the current year be appropriated and placed at the disposal of the Board of Government for use in payment of the current expenses of the Society.

On motion duly made and seconded, the above vote was passed unanimously.

The Secretary read the following reports:

REPORT OF JOINT COMMITTEE ON LICENSING ENGINEERS.

To the Members of the

BOSTON SOCIETY OF CIVIL ENGINEERS, BOARD OF GOVERNMENT; BOSTON SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; BOSTON SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS; BOSTON SOCIETY OF ARCHITECTS; BOSTON CHAPTER, AMERICAN ASSOCIATION OF ENGINEERS; BOSTON SECTION, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS; BOSTON SECTION, AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS; BOSTON SOCIETY OF LANDSCAPE ARCHITECTS:

Gentlemen, — The Committee of the Boston Society of Civil Engineers appointed to consider the matter of the licensing of engineers, being of the opinion that a statute providing for the registration of professional engineers should also cover all branches of the professions of engineering and architecture, recommended that its membership should be enlarged to include one representative each from other engineering and architectural societies.

The President of the Boston Society of Civil Engineers, on request of this committee and with the authorization of the Board of Government, invited representatives from such other professional organizations to join with the committee of the Boston Society of Civil Engineers, and representatives were appointed by the following societies:

Boston Section, American Institute of Electrical Engineers.
Boston Section, American Society of Mechanical Engineers.
Boston Society of Architects.
Boston Chapter, American Association of Engineers.
Boston Section, American Society of Heating and Ventilating Engineers.

Boston Section, American Institute of Mining and Metallurgical Engineers.

Boston Society of Landscape Architects.

The committee of the Boston Society of Civil Engineers and the representatives of the above-named societies voted to form and act as a joint committee. The chairman was requested to prepare a draft of a proposed law for the registration of architects and engineers by the Commonwealth, it being voted not to include land surveyors. Subcommittees were requested to prepare arguments in favor of and against such registration. This work was done, a tentative bill and the arguments pro and con being submitted to all the members of the committee.

On January 4, 1921, a bill was filed in the legislature by the Boston Chapter, American Association of Engineers, to regulate the practice of the profession of engineering and land surveying.

At a meeting of the joint committee held on January 7, 1921, it was voted:

1. That legislation relative to the registration of architects and engineers by this year's session of the legislature should not be recommended.

2. That the Boston Chapter, American Association of Engineers, be requested to withdraw, for this year, its bill filed with the legislature to regulate the practice of the profession of engineering and land surveying.

Respectfully submitted as a report of progress.

(Signed)

CHARLES W. SHERMAN,
CHARLES M. SPOFFORD,
CHAS. R. GOW,
CHARLES T. MAIN,
I. E. MOULTROP,
EDWIN H. ROGERS, *Chairman*,
Representing BOSTON SOCIETY OF CIVIL ENGINEERS.

L. W. ABBOTT,
Representing BOSTON SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

A. L. WILLISTON,
Representing BOSTON SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

C. H. BLACKALL,
Representing BOSTON SOCIETY OF ARCHITECTS.

ALLEN HUBBARD,
Representing BOSTON SECTION, AMERICAN SOCIETY HEATING & VENTILATING ENGINEERS.

GEO. A. PACKARD,
Representing BOSTON SECTION, AMERICAN INST. MINING & METALLURGICAL ENGINEERS.

BREMER W. POND,
Representing BOSTON SOCIETY OF LANDSCAPE ARCHITECTS.

JANUARY 19, 1921.

TO BOSTON SOCIETY OF CIVIL ENGINEERS:

The undersigned, representative of Boston Chapter, American Association of Engineers, invited on your Committee for the Registration Bill, takes the liberty to submit a minority report recommending:

To support the Engineers' Registration Bill already entered by Boston Chapter, American Association of Engineers,
for the following reasons:

1. The urgent need of registration of engineers does not warrant postponing the bill until next year, and the last day for entering bills for this legislature is passed.

2. Boston Chapter, American Association of Engineers, has been working on the bill for over a year, has studied those of other states and the working of same, and has employed competent legal advice on the draft of the bill.

Respectfully submitted,

(Signed) HARRY SHARPE,
Chairman, Legislative Committee,
Boston Chapter, American Association of Engineers.

By vote, the reports were accepted and placed on file.

Professor Spofford submitted the following motion, which was duly seconded:

"That it is the sense of this meeting that in view of the importance of having uniformity of registration laws in all states, and the fact that such laws have in some states proven to be inoperative and are now in process of amendment, the Committee on Registration of this Society be authorized to represent the Society before the Legislature in favor of having the bill for Registration of Engineers and Surveyors now before the Legislature referred to the next General Court."

After a discussion in which Professor Spofford and Messrs. Metcalf, Monaghan, Rogers and Guppy of the Society, and Dr. Frederick H. Newell, a past president of the American Association of Engineers, took part, the motion was lost.

The hour for the literary exercises having arrived, the President introduced Mr. Roderick B. Young, senior assistant laboratory engineer, in charge of engineering materials and chemical division of the Hydro-Electric Power Commission of Ontario, who read a paper entitled, "New Methods of Proportioning Concrete in Theory and Practice." The paper was illustrated with numerous slides.

At the conclusion of the reading of the paper, Capt. L. N.

Edwards contributed a short but most interesting discussion on the subject of the paper.

On motion of Prof. L. J. Johnson, the thanks of the Society were voted to Mr. Young and Captain Edwards, for their interesting contributions.

The President submitted for the Board of Government its recommendation that the Society join the Federated American Engineering Societies. The President stated that the Board had carefully considered the cost involved in such action and had come to the conclusion that the additional expense could be met without increasing the dues or curtailing the present activities of the Society. One method which had been suggested was that there be sent out, with the bill for dues for the coming year, an invitation to members interested in this action by the Society, to contribute a small sum, not exceeding two or three dollars each, towards the dues for membership in the Federation.

Colonel Gunby moved, and it was duly seconded, That it is the sense of this meeting that the Boston Society of Civil Engineers should join the Federated American Engineering Societies and that this matter be referred to the membership by letter ballot. On a vote being taken the motion was carried.

The Secretary announced that a canvass by the Board of Government of the letter ballot on the adoption of the "Resolutions concerning a proposed amendment of the Federal Water-Power Act" printed in the January JOURNAL of the Society under the Minutes of the December, 1920, meeting, showed the following result: 297 voted yes, and 10 voted no.

The President announced the death of Edmund M. Blake, a member of the Society, which occurred on January 12, 1921. The President has named the following committee to prepare a memoir of Mr. Blake: Messrs. Henry A. Symonds and L. Leroy Hammond.

The Secretary presented a memoir of William M. Brown, a member of the Society, who died May 28, 1920, prepared by a committee consisting of Messrs. Howard A. Carson and Henry T. Stiff, and by vote it was accepted and ordered printed in the JOURNAL.

At 10.10 o'clock the Society adjourned.

S. E. TINKHAM, *Secretary.*

Boston, Mass., January 5, 1921. — A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society Rooms, Tremont Temple. The meeting was called to order at 7.40 P.M. by Chairman Edward Wright.

The records of the December meeting were read and approved.

Copies of the reports of the Special Plumbing Board of the Massachusetts Department of Public Health, on "The Advisability of Standardizing Municipal Regulations Relating to Plumbing and Drainage," were distributed.

This report was discussed by Prof. George C. Whipple, of the Department of Public Health; Edward C. Kelly, of the Massachusetts State Association of Master Plumbers; Dana Somes, of the Boston Society of Architects; Bertram Brewer and Erastus Worthington.

On motion of Mr. Wentworth it was *voted:* "That a committee of three be appointed by the Chairman to study the report of the Special Plumbing Board and to aid in securing legislation to revise the plumbing rules."

The Chairman then introduced Dr. L. L. Williams, past assistant surgeon, U. S. Public Health Service, who spoke on "Rat Extermination and Proofing in Its Relation to the Prevention of Plague."

Dr. Williams described his experiences in rat-proofing and extermination at New Orleans and other cities.

The subject was discussed by Mr. H. C. Mosman, of the Massachusetts Department of Health.

On motion of Mr. Marston, a rising vote of thanks was given Dr. Williams, Mr. Mosman, Mr. Kelly and Mr. Somes, for their courtesy in speaking to the Society.

Adjourned at 10.00 P.M.

Members present, 30.

John P. Wentworth, *Clerk.*

Boston, December 8, 1920. — A regular meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.10 this evening, by Chairman Ralph W.

Horne. After the minutes of the previous meeting were read and approved, Mr. George A. Sherron was introduced, and addressed the Section upon the subject, "Modern Concrete Road Construction; Machinery and Methods."

His instructive talk was well illustrated by lantern slides and three reels of motion pictures.

The meeting adjourned at 8.25 P.M.

Respectfully submitted,

A. L. SHAW, *Clerk.*

JANUARY 12, 1921. — The regular January meeting of the Designers Section was called to order at 6.10, Chairman Horne presiding. The reading of the minutes of the last meeting was omitted on account of the absence of the Clerk. There were 33 present.

Mr. J. G. Rae, of the Turner Construction Company, spoke upon the subject of "Practical Design from the Contractor's Point of View," pointing out common difficulties in construction and bringing many valuable suggestions before the meeting. Mr. Percy Mosher, of the Boston Transit Commission, opened the discussion, presenting several new thoughts; and a very lively discussion followed.

After extending to the speaker a rising vote of thanks, the meeting adjourned at 7.30 P.M.

A. L. SHAW, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[February 15, 1921.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which

will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Boyd, Walter Eugene, Hudson, Mass. (Age 30, b. Cochituate, Mass.) From 1910–12 studied civil engineering at Brown University; 1912–13, worked with Erwin O. Hathaway, city engineer of Nashua, N. H., as chainman, rodman, etc., on municipal and private surveys; 1913–16, on the Panama Canal, doing field and office work on hydrographic and topographic surveys, supervising dredging with the Dredging Division; 1916–17, with the building department of the General Electric Co.; 1917–18, was first lieutenant in 102d Infantry; 1919 to date, with the General Electric Co., on building estimates and computations. Refers to W. M. Bailey, E. O. Hathaway, W. D. Morrill and F. J. McCann.

Connor, Bernard Dominic, Somerville, Mass. (Age 25, b. Proctor, Vt.) Graduated from Somerville High School in 1913, and from Tufts Engineering School in 1917. Previous to graduation, in 1915, spent three months as rodman, levelman and draftsman in mining survey in Virginia; 1916, three months as engineer and inspector on electric conduit construction in Charlestown, and two months during college year as draftsman on conduits, etc., with the Charlestown Gas & Electric Co.; in 1917 had five months with the N. Y., N. H. & H. R. R., as rodman on construction of railroad yard facilities, etc.; and two months with the Aberthaw Construction Co.; 1918–19, was in the Engineers Regiment for eighteen months; 1919–20, with the City Engineer of Lynn: 1920–21, with the J. G. White Engineering Corp. on a water-power survey in the Adirondacks, as chief of party on stadia survey. Refers to M. H. Mellish, J. W. Raymond, Jr., E. H. Rockwell, F. B. Sanborn, A. S. Tuttle, W. L. Vennard and J. P. Wentworth.

Flynn, Francis G., Dorchester, Mass. (Age 23, b. Roxbury, Mass.) Graduate of Boston English High School in 1916, of Lowell Institute in 1917, and a student in civil engineering at Northeastern College 1917–18. Worked as chainman in the Public Works Department, Boston, during the summers of 1912–13; draftsman, inspector and estimator with the Boston Wharf Co., 1915–19; rodman and inspector with the B. & M. R. R., 1920–21. Refers to S. P. Coffin, P. Jones, J. J. Rourke and W. A. Woods.

Horgan, Jeremiah J., Fitchburg, Mass. (Age 30, b. Fitchburg, Mass.) Took civil engineering course with the International Correspondence School, 1910–16, nearly completed; 1920–21, Mass. University Extension course in elements of structures, about half completed; 1910–15, was rodman and

transitman with Pratt & Davis, Fitchburg, Mass.; 1915–17, was transitman with the City of Fitchburg; 1917–19, was chief of party with Parker, Bateman & Chase, Fitchburg; 1919 to date, chief of field party in construction, Boston & Albany R. R., South Station. Refers to F. W. Bateman, J. G. Brackett, G. H. Chase, A. Curtis and E. E. Lothrop.

Macauley, Ralph Fairfield, Cambridge, Mass. (Age 22, b. Boston, Mass.) Graduate of Mechanic Arts High School in 1917; took a course in civil engineering at Tufts in summer of 1918, and at present is taking last year at evening school of engineering at Northeastern College. From 1918 to the present time, with the Division Engineer of the B. & M. R. R., at present as rodman. Refers to S. P. Coffin, P. Jones, J. J. Rourke and W. A. Woods.

MacWilliams, Harold Freeman, Newburyport, Mass. (Age 19, b. Boston, Mass.) Took a three years' course in the Newburyport High School, then an intensive course at the Huntington School, followed by a year in civil engineering at Northeastern College. Is at present taking a course at Mass. University Extension. During summer vacations worked as rodman and transitman with E. H. Lincoln Co., and the Essex County Engineers; at present with the Department of Public Works, Division of Highways, as inspector on road construction. Refers to A. B. Appleton, A. W. Dean, A. M. Lovis, A. P. Rice and W. N. Wade.

Mueser, William Henry, Boston, Mass. (Age 20, b. Bronx, New York City.) At present, third-year student at Mass. Institute of Technology. During the summer of 1918 worked with the Concrete Steel Engineering Co., New York City, drafting; the summer of 1920 at Mass. Institute of Technology summer surveying camp at East Machias, Me. Refers to J. B. Babcock, 3d, C. B. Breed, J. W. Howard, G. L. Hosmer, H. B. Luther and A. G Robbins.

Sloan, Joseph Warren, Charlestown, Mass. (Age 24, b. Dorchester, Mass.) Graduate of Mechanic Arts High School in 1915, a school in France in 1918, and studied civil engineering at Northeastern College 1919–20. Was rodman for J. B. McClintock during the summer of 1914; rodman for Metropolitan Park Commission in 1919, and for the Metropolitan Water Works in 1920; rodman for Division Engineer of the B. & M. R. R. in 1921. Refers to S. P. Coffin, P. Jones, J. J. Rourke and W. A. Woods.

Sullivan, Thomas Francis, Boston, Mass. (Age 43, b. Boston, Mass.) With Boston Elevated Railway Company, from April, 1899, to March, 1905, as timekeeper and clerk; March, 1905, to Oct., 1909, chief clerk; Oct., 1909, to Sept., 1912, assistant superintendent of tracks; Sept., 1912, to April, 1918, roadmaster of surface lines. From April, 1918, to date, commissioner of public works, City of Boston. Refers to E. S. Dorr, C. T. Fernald, H. C. Hartwell, A. T. Sprague, Jr., H. M. Steward and F. O. Whitney.

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of positions available and the other of men available, giving in each case detailed information in relation thereto.

Men Available.

No. 520. Age 26. Six months' experience installing and inspecting thermostatic heating control devices; a year and a half drafting and compiling cost data for valuation purposes; nearly two years in U. S. Army, Corps of Engineers, on various engineering work; nine months compiling insurance schedule. Salary desired, $175 per month.

No. 521. Age 24. Five years' experience in structural design and detailing; one year in architectural drawing. Desires position as structural draftsman. Salary desired, $40 per week.

No. 522. Age 26. Graduate of Worcester Polytechnic Institute. Experience, drafting one year, and two years engineer on dry-dock construction. Desires field engineering work. Salary desired, $200 per month.

No. 523. Age 27. Graduate Lynn Classical High School, and Dartmouth College, 1915. Experience, transitman with B. & M. R. R., draftsman with N. Y., N. H. & H. R. R., railroad engineer on construction. Salary desired, $36 per week minimum.

No. 524. Age 25. Graduate Massachusetts Institute of Technology, 1918. Experience, seven months drafting and designing concrete, nine months construction and field engineering. Desires position as construction engineer and salary of $2 500 a year.

No. 525. Age 39. Graduate Lowell schools, also took a course with American Institute. Experience, seven years as rodman and transitman on construction, seven years as transitman and draftsman on subway construction, two years on Merrimack River survey, two years at Squantum plant as civil engineer. Desires position as inspector or transitman at a salary of $35 per week.

No. 526. Age 37. High school education, also attended Y. M. C. A. Experience, sixteen years in street railway drafting, laying out and designing special work, one year as assistant engineer laying out track and giving line and grade. Desires position as draftsman or transitman at a salary of $30 per week.

No. 527. Age 27. Graduate Lehigh University, degree of C.E. Special studies in mechanical and mining engineering. Experience, five years

as assistant to general superintendent of shipbuilding corporation on steel fabrication, etc., eight months steel mill building construction, and fourteen months railroad engineering. Desires position as production superintendent in steel construction work, at a salary of $2 500 a year.

No. 528. Age 24. Graduate of High School, one year Wentworth Institute (construction course), two and a half courses completed in Mass. University Extension, and two years evening school, Framingham High School. Experience, one year sugar refinery machinery, four months designing piping layouts, one year as assistant engineer. Desires position as assistant engineer in factory or machine shop at a salary of $175 a month.

No. 529. Age 30. Graduate Worcester Polytechnic Institute. Experience in structural steel erection, oil tank and oil refinery erection, concrete construction, estimator, right-of-way grants, gas plant erection and concrete detailing. Desires position as concrete designer or estimator or resident engineer on concrete construction, at a salary of $50 per week.

No. 530. Age 25. Graduate Dorchester High School, evening technical school, two years at Wentworth Institute and two years at Franklin Union. Experience, one year structural steel and mechanical conveying equipment, one year mechanical lay-out and oil-burning installation, one year machine detail and structural drafting. Desires position as draftsman at $30 per week.

No. 531. Age 25. Graduate of Northeastern Engineering School. Experience, three years land surveying, one year railroad work and six months drafting. Desires a salary of $30 per week.

No. 532. Age 25. Graduate of Tufts College 1917, with degree of C.E. Experience as rodman and level man in mining survey, as inspector and engineer on electric conduit construction, as transitman on concrete and steel buildings, eighteen months with U. S. Engineers (23d) on technical work in France, in surveys, testing materials, inspecting and in charge of street work in a city engineer's office. Desires position as chief of party, resident engineer or assistant engineer, at a salary of $50 per week.

No. 533. Age 23. Graduate Mechanic Arts High School, 1915. Now attending Lowell Institute, second year, building course. Experience, transitman on railroad, chief of party on development work. Desires position as transitman or inspector at a salary of $25 per week.

No. 534. Graduate of Mass. Institute of Technology in structural architecture. Experience, eighteen years inside and outside work with consulting engineers, corporations, etc., as designer in office and superintendent in field, outside superintendent of reinforced concrete office and factory, resident engineer on construction of a chemical plant, then plant engineer of same, structural engineer of auto-tire plant and offices. Desires position as a structural engineer for corporations, or for general contractors.

LIST OF MEMBERS.

ADDITIONS.

ARCHIBALD, HENRY C. ..... 163 Hancock St., Everett, Mass.
CHASE, WILLIAM H. ..... 216 Middle St., New Bedford, Mass.
CLARK, THEODORE PARKER ..... 6 Ridgway St., Winchester, Mass.
KEITH, SCOTT ..... 14 Beacon St., Boston, Mass.
KRIGGER, ANSELMO ..... 51 Dana St., Cambridge, Mass.
LUCAS, JOHN ..... 86 Eastern Ave., East Lynn, Mass.
NEWCOMB, GEORGE H. ..... 75 Glendale Rd., Quincy 69, Mass.
ROSE, BERNARD S. (with Charles T. Main),
201 Devonshire St., Boston, Mass.
TRAVERS, J. FRANCIS, Jr. ..... 55 Hampden Hall, Cambridge, Mass.

CHANGES OF ADDRESS.

BELLAMY, ROBERT BAYARD ... 25 Elden St., Grove Hall P. O., Boston, Mass.
BURLEIGH, WILLARD G. ..... 40 Waverley St., Waverley, Mass.
BROWN, WILLIAM A. ..... 99 Orient St., East Boston, Mass.
CANNON, MADISON M. ..... 88 Broad St., Boston, Mass.
CHAPMAN, B. R. ..... 61 Turner St.. Brockton, Mass.
HODGES, ARTHUR W. ..... 487 So. Main St., Randolph, Mass.
O'BRIEN, JOSEPH H., Care Foundation Co., 120 Liberty St., New York, N. Y.
RHODES, RALPH F. ..... Care U. S. Engrs. Office, Muscle Shoals, Ala.
ROBINSON, ASHLEY Q. ..... 276 Church St., Newton, Mass.
SMALL, GILBERT ..... Care J. R. Worcester & Co., 79 Milk St., Boston, Mass.
SAWYER, GEORGE A. ..... 30 No. Franklin St., Wilkes-Barre, Pa.
TOSI, JOSEPH A. ..... 2 Kingsbury St., Worcester, Mass.
TUCKER, LESTER W. ..... Ch. Engr., Henry R. Kent & Co., Rutherford, N. J.
WAITE, EDWARD B. ..... Drawer 946, Westboro, Mass.
WEBB, GEORGE F. ..... Box 223, Douglasville, Ga.
WOOD, WILLIAM A. ..... 149 Tremont St., Boston, Mass.

DEATHS.

VAUGHAN, LOUIS B. ..... July 23, 1920
SCORGIE, JAMES C. ..... February 16, 1921

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Annual Report, Director United States Coast and Geodetic Survey, 1920.

Report of Librarian of Congress, June 30, 1920.

Annual Report on Statistics of Express Companies, 1919.

Interpretative Report of U. S. Council of National Defense, Woman's Committee, April, 1917, to February, 1919.

State Report.

Massachusetts. Annual Report of Highway Commission. 1919.

Massachusetts. Annual Report of Commission on Waterways and Public Lands. 1919.

Massachusetts. Annual Report of Homestead Commission. 1919.

Massachusetts. Industrial Review No. 3, October, 1920.

New York. Annual Report Public Service Commission. 2 vols. 1917.

Wisconsin. Wisconsin Survey. Bulletin No. 57.

Municipal Reports.

Boston, Mass. Annual Report City Planning Board. 1919.

Miscellaneous.

Defend Your Steam. Magnesia Association of America.

Production of Iron and Steel in Canada. 1919.

Quebec Bridge Inquiry, Vol. 2. 1908.

Railway Statistics of United States. Slason Thompson. 1919.

Steel Railway Bridges. Edward C. Dilworth.

White Lead — Its Use in Paint. A. H. Sabin.

LIBRARY COMMITTEE.

Vol. VIII MARCH, 1921 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"The New Methods of Proportioning Concrete, in Theory and Practice." By Roderick B. Young.

"Several Years' Experiments on the Disposal of Worcester Sewage." By Roy S. Lanphear.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, February 16, 1921. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Frank A. Barbour.

There were 108 members and visitors present.

The records of the last meeting were read and approved.

The Secretary reported for the Board of Government, the election to membership of the following candidates in the grades named:

Members — Henry T. Burrage, William H. Cronin, John J. Murphy, Frank J. Nowell, Percy A. Shaw.

Juniors — Eugene Mirabelli, Merritt P. Smith, George N. Watson.

Mr. Winslow moved the adoption of the following vote, which was passed at the last meeting, and it was carried unanimously:

Voted: That the entire income of the Permanent Fund for the current year be appropriated and placed at the disposal of the Board of Government for use in payment of the current expenses of the Society.

The President announced the death of Louis B. Vaughan, which occurred on July 23, 1920, and by vote he was authorized to appoint a committee to prepare a memoir.

The speaker of the evening, Mr. William N. Connor, was then introduced. Mr. Connor presented a most interesting paper, entitled "Construction Costs," which was illustrated with lantern slides.

The paper was discussed by Messrs. Leonard C. Wason, J. Arthur Garrod, Luzerne S. Cowles and others.

After passing a vote of thanks to Mr. Connor, on motion of Mr. Cowles the Society adjourned at 9.10 o'clock.

S. E. Tinkham, *Secretary.*

Boston, February 2, 1921. — A meeting of the Sanitary Section was held in the Society Rooms, and was opened at 7.50 P.M. by Chairman Edward Wright. The minutes of the previous meeting were read and approved.

The Chairman announced the appointment of the special committee on Plumbing Regulations, authorized at the last session, as follows: Messrs. R. S. Weston, H. A. Varney and E. H. Rogers.

It was moved, seconded and carried, that the Chairman appoint a committee of three to report nominations of officers for the ensuing year at the next meeting.

The Chairman suggested that there be a dinner prior to the annual meeting, March 2. There being no expression of objection, Mr. Wright stated that arrangements to that end would be made and the place of the dinner announced in the notice for the meeting.

Mr. R. S. Lanphear was then introduced and held the interest of his audience of 32 with his address upon "Several Years' Experiments in the Treatment of Worcester Sewage." His description of the conduct and results of the experimental work at Worcester which lead to the adoption of the Imhoff Tank-Trickling Filter method in preference to the Activated Sludge Process, on account of the unusual character of the Worcester sewage, was followed by general discussion.

Mr. Fales moved a rising vote of thanks to the speaker, and the meeting was adjourned at 10 P.M.

Respectfully submitted,

A. L. Shaw, *Acting Clerk.*

February 9, 1921. — A meeting of the Designers Section was called to order at 6.08 P.M., with Chairman Ralph W. Horne presiding.

There were 40 present.

The minutes of the previous meeting were read and approved. A motion was carried that the Chairman appoint a committee of three to report, at the annual meeting, nominations of officers for the ensuing year. Howard Thomas, E. S. Parker and F. A. Marston were named for this committee.

Mr. John R. Nichols was then introduced and outlined the principles and practices with respect to "Flat Slabs — Design and Building Codes," illustrating variations in the dependence which the framers of codes in various cities have seen fit to place upon the peculiar characteristics of this type of construction. A general discussion followed, in the course of which Mr. F. A. Marston described an unusual special problem in flat slab design which he had recently had to meet.

After extending a vote of thanks to Mr. Nichols the meeting adjourned at 8.05 P.M.

Respectfully submitted,

A. L. Shaw, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[March 15, 1921.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Allen, John Stetson, Walpole, Mass. (Age 53, b. Walpole, Mass.) After leaving high school did office work for two or three years, then learned carpenter's trade and later, in partnership with his father, conducted a contracting business, and gradually worked into various forms of general contracting and building. At present is president and treasurer of the M. W. Allen Construction Co., Walpole, Mass. Refers to C. M. Allen, J. M. Cashman, G. A. Sampson and R. S. Weston.

Conger, Alger Adams, Worcester, Mass. (Age 45, b. Gouverneur, N. Y.) Graduate of Cornell University 1897, with degree of C.E. From 1897–99 worked with U. S. Board of Engineers on Deep Waterways on ship canal surveys, plans and estimates; 1899–1900 with the Isthmian Canal Commission on surveys and estimates for Panama Canal; 1900–1 with New York State Barge Canal; 1901–3 with Michigan Lake Superior Power Co., asst. engineer in charge of power house and dock construction; 1903–6 with New York State Barge Canal in charge of plans and specifications for contracts canalized river locks and fixed dams; 1906–11 with J. G. White & Co., assistant hydraulic engineer, water-power development; 1911 to date, hydraulic engineer, Power Construction Co. and New England Power Co., on development, maintenance and operation of power plants and storage. Refers to C. M. Allen, H. K. Barrows, A. C. Eaton and G. G. Shedd.

DeMerritt, Robert Elwyn, Fort Sherman, Canal Zone, Panama. (Age 27, b. Orange, Mass.) September, 1912, to February, 1914, student at Mass. Inst. of Tech.; summer of 1914, rodman and transitman for C. E. Carter, Reading, Mass.; 1914–15, student at Tech.; September, 1915, to January, 1916, draftsman and assistant engineer, Bay State Railway; February, 1916, to June, 1917, student at Tech.; summer of 1916, transitman, chief of party and inspector, Sewer Division, Woonsocket, R. I.; September to November, 1917, inspector and assistant engineer, Sewer Division, Constructing Quartermaster's office, Camp Devens, Mass.; November, 1917, to May, 1918, 2d Lieut., Coast Artillery Corps, U. S. Army; May, 1918, to date, 1st Lieut., Coast Artillery Corps, U. S. Army. Now at Fort Sherman, Canal Zone. Refers to C. E. Carter, H. F. Davis, G. L. Hosmer and J. W. Howard.

Steward, Douglas Patten, Medford, Mass. (Age 19, b. Lynn, Mass.) Three years as rodman with the B. & M. R. R., and at present is a sophomore at Tufts Engineering School. Refers to R. Abbott, S. P. Coffin, J. J. Rourke, A. T. Sprague, Jr., H. M. Steward and W. A. Woods.

LIST OF MEMBERS.

ADDITIONS.

Cronin, Walter L. ..... 51 Claybourne St., Dorchester, Mass.
Holbrook, Parker ..... 6 Hancock St., Winchester, Mass.
Leary, Charles A. ..... 6 Beacon St., Boston 9, Mass.
Martin, Albert A. ..... 505 Centre St., Milton 86, Mass.
Mirabelli, Eugene ..... 20 Pleasant St., Dorchester 25, Mass.
Murphy, John J. ..... 4 Deering Road, Boston 26, Mass.
Nowell, Frank J. ..... 20 Danville St., W. Roxbury, Mass.
Smith, Merritt P. ..... 25 Linwood St., Arlington, Mass.
White, David J. ..... 62 Condo St., East Boston, Mass.
Wright, Frank V. ..... 14 Forrester St., Salem, Mass.

CHANGES OF ADDRESS.

Bissell, H. ..... 21 Esther St., Pasadena, Calif.
Brown, C. Leonard ..... 810 Taylor St., N. W., Washington, D. C.
Brown, T. Morris ..... 52 S. Arlington Ave., East Orange, N. J.
Burleigh, Willard G.,
Care The Man Message Corp., 620 Fifth Ave., New York, N. Y.
DePuy, Clarence S. ..... Halifax Hotel, Halifax, N. S.
Fair, Gordon M.,
Care League of Red Cross, 9 Cour de St. Pierre, Geneva, Switzerland.
Hodges, A. W. ..... 489 So. Main St., Randolph, Mass.
Stearns, Ralph H. ..... Room 3112, 120 Broadway, New York, N. Y.
Tucker, Francis C. ..... 1938 Home Ave., Rogers Park, Chicago, Ill.
Umstead, Charles H. ..... 331 C St., N. W., Washington, D. C
Wood, Leonard P. ..... Asst. Designing Engr., Board of Water Supply, 2200 Municipal Bldg., New York, N. Y.

DEATHS.

ANDREWS, DAVID H. ..... February 24, 1921.
BILDT, AUGUST F. ..... February 14, 1921.
SCORGIE, JAMES C. ..... February 16, 1921.
VAUGHAN, LOUIS B. ..... July 23, 1921.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Chief of Weather Bureau Report. 1919–1920.

Chief of Engineers of U. S. Annual Reports. 1920. 3 vols.

Primary Traverse in Iowa, Kansas, Missouri, Nebraska and Oklahoma. 1916–18.

Triangulation and Primary Traverse in Kentucky and Tennessee. 1916–18.

Triangulation in Maine and New Hampshire. 1916–18.

Utilization of Black Walnut. Bulletin No. 909.

Water Supply Paper No. 467.

State Reports.

New Hampshire. Annual Report, Public Service Commission. 1919.

New Hampshire. Report of Commission on Water Conservation and Water Power. 1919–1920. Geo. B. Leighton, in coöperation with U. S. Geol. Survey.

Municipal Reports.

Lynn, Mass. Annual Report, Commissioner of Water Supply. 1919.

Erie, Pa. Annual Report, Commissioners of Water Works, 1918 and 1919.

Miscellaneous.

Aberthaw Tests on Concrete in Sea Water.

Construction of Roads and Pavements. Agg.

Phosphate in Canada. H. S. Spence, M.E.

Report on Road Materials along the St. Lawrence River. R. H. Picher.

Report on Proportioning Concrete. R. B. Young.

Report on Concrete Aggregate Investigations. R. B. Young and W. D. Walcott.

Ships and Shipmasters of Old Providence.

The Quebec Bridge. By St. Lawrence Bridge Co.

LIBRARY COMMITTEE.

TYPOGRAPHICAL ERROR

Memoir of William M. Brown — February Journal, page 70, line 7, change sewerage to read sewage.

The committee wishes to emphasize that this word was correctly used in the original manuscript.

—EDITOR.

Vol. VIII APRIL, 1921 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Address at the Annual Meeting." Frank A. Barbour.

"The Responsibility of Organized Labor for the Stagnation in the Building Industry." Charles R. Gow.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, March 16, 1921.— The seventy-third annual meeting of the Boston Society of Civil Engineers was called to order in Rooms A and B of the Boston City Club, on Wednesday, March 16, 1921, at 5.15 o'clock P.M., by the President, Frank A. Barbour, and the records of the last meeting of the Society were read and approved. There were about 125 present at the meeting.

The Secretary reported for the Board of Government that it had elected the following candidates to membership in the grades named:

Members — Messrs. Walter E. Boyd, Bernard D. Connor, Thomas J. Haggerty, Jeremiah J. Horgan and Thomas F. Sullivan.

Juniors — Messrs. Francis C. Flynn, Ralph F. Macaulay, Harold F. MacWilliams, William H. Mueser, Joseph T. Shea and Joseph W. Sloan.

The President announced the result of the letter ballot on the Society's joining the Federated American Engineering Societies, the vote being 322 in favor and 37 against.

The President presented a report made to the Board of Government by a committee representing a number of professional societies in Boston, in relation to the possible establishment of some form of association for bringing together in a manner that might make more easy the coöperation of engineers in this vicinity upon questions and welfare work of interest to them.

By vote the report was referred to the incoming Board of Government of the Society, with full powers.

The annual reports were then taken up.

The President read the annual report of the Board of Government. Later, by vote, it was accepted and the recommendations referred to the incoming board with full powers.

The Treasurer then read his annual report, which was by vote accepted and placed on file.

The Secretary read his annual report, which was accepted and placed on file.

The report of the Committee on the Library was read by the Librarian, and that of the Committee on Social Activities by its chairman, Mr. Berry, both of which were accepted and placed on file.

Mr. Safford, chairman of the Committee on Run-Off Available for Water-Power Purposes, presented a very full report, the result of its four years of careful work, and made a brief statement in regard to the report. By vote the report was accepted and the sincere thanks of the Society were extended to the committee for its valuable work.

The report of the Committee on Licensing Engineers was read by its chairman, Mr. Rogers. By vote the report was accepted and its recommendations referred to the incoming Board of Government for action.

On motion of Mr. Metcalf, the reappointment of the several special committees of the Society was referred to the incoming Board of Government, with full powers.

The Secretary, for the Tellers of election, Messrs. Horace H. Chase and Henry T. Stiff, submitted the result of the letter

ballot for officers of the Society, and in accordance with their report the following officers were declared elected:

President — Robert Spurr Weston.
Vice-President (for two years) — Edwin H. Rogers.
Secretary — S. Everett Tinkham.
Treasurer — Frank O. Whitney.
Directors (for two years) — Edgar S. Dorr and Richard K. Hale.
Members of the Nominating Committee (for two years) — Charles R. Berry, Edward S. Larned and Charles R. Main.

In the absence of Mr. Harrison P. Eddy, to whom the Desmond FitzGerald Medal had been awarded, the President asked the chairman of the Committee on the Award of the Medal, Mr. Richard A. Hale, to present the medal at an early date on behalf of the Society.

The President announced the deaths of the following members of the Society: James C. Scorgie, who died February 16, 1921; August F. Bildt, who died February 14, 1921, and David H. Andrews, who died February 24, 1921.

The retiring President, Mr. Frank A. Barbour, then delivered the annual address of the President, which will be printed in the April number of the JOURNAL.

Before leaving the chair the President introduced the President-elect, Mr. Robert Spurr Weston, who expressed his appreciation of the honor conferred on him in the election to this office and outlined briefly some of the work before the Society for the coming year.

At 6.20 o'clock the members adjourned to the main auditorium of the clubhouse, where the annual smoker was held. The usual supply of pipes and tobacco was ready when the doors were opened at half past six, and the refreshments, spread on tables extending the full length of one side of the banquet room, were declared to be the best the City Club had ever provided in the thirteen years it has catered for our smokers.

Music was furnished by Haskell's Orchestra, which also furnished accompaniments for the community singing, under the energetic leadership of Walter Cowlishaw. Entertainment

was furnished by Allen and Clark, comedy musicians; Daley and Thomas, acrobats, and Sam Bailey, sleight-of-hand performer. A pleasing innovation this year was a recitation by a member, Mr. Monaghan, of that baseball classic, "Casey at the Bat." Hardly had the applause subsided when a guest, with profuse apologies for breaking in on the harmony of the gathering, craved permission to be heard for three minutes in which to refute the accusation of lack of prowess by that famous batter. In this plea he was so ably seconded by his host, that the master of ceremonies invited the objector to the platform. The round of applause which greeted the recital of "Casey's Revenge" was faint in comparison with that which arose when those present realized that the whole incident was a frame-up.

The arrangements for the entertainment at the smoker were in the hands of the Committee on Social Activities, and again they scored a most successful evening.

The attendance at the smoker was 210, and the total attendance of members and guests at both functions was over 250.

S. E. TINKHAM, *Secretary.*

BOSTON, March 24, 1921.— A special meeting of the Boston Society of Civil Engineers was held this evening in Lorimer Hall, Tremont Temple, Boston, and was called to order by the President, Robert Spurr Weston, at 8.10 o'clock.

Col. Charles R. Gow, a past president of the Society, was at once introduced and spoke most interestingly for nearly an hour and three quarters, taking for his subject "The Responsibility of Organized Labor for the Present Stagnation in the Building Industry."

At the conclusion of his talk the Society adjourned.

The attendance of members and guests was nearly 300.

S. E. TINKHAM, *Secretary.*

Annual Meeting of the Sanitary Section.

Boston, March 2, 1921.— The Sanitary Section of the Boston Society of Civil Engineers held its annual meeting this evening.

At 6.00 P.M. 21 members of the Section held an informal dinner at the Boston City Club.

At 7.45 P.M. the business meeting was called to order in the Society Rooms, by the Chairman, Edward Wright.

The records of the February meeting were read and approved.

The annual report of the Executive Committee was read and accepted.

Mr. Frank S. Bailey, for the Nominating Committee, submitted the following nominations for the ensuing year:

Chairman — Harold K. Barrows.
Vice-Chairman — Alfred O. Doane.
Clerk — John P. Wentworth.
Executive Committee —
Arthur D. Weston.
Henry V. Macksey.
George W. Bowers.

On motion of Mr. Fales, the Clerk was instructed to cast one ballot for the officers as nominated.

Prof. Dwight Porter reported for the Committee on Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water. This report, although not in final form, covered the subject very thoroughly and was very instructive to the members of the Section.

On motion of Mr. Eddy, it was voted that the report be accepted and the committee continued.

Mr. Edgar S. Dorr made a progress report for the Committee on Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers.

A written report was received from the Committee on the Proposed Rules and Regulations of the Special Plumbing Board of the State Department of Health. This report was discussed at length by several of the members.

On motion of Mr. Gow, the following resolution was passed:

"*Whereas* existing plumbing regulations in force throughout the Commonwealth are neither uniform nor economical nor always in accordance with the best sanitary engineering practice,

"*Be it resolved* by the Sanitary Section of the Boston Society of Civil Engineers that the principles of uniform plumbing regulations throughout the Commonwealth be embodied in the laws of the Commonwealth."

On motion of Mr. Eddy, it was voted "That a committee of three members be appointed by the Chairman to appear at the legislative hearing and present the above resolution and the views of the members as presented at this meeting."

Chairman Wright then presented the incoming Chairman, Prof. Harold K. Barrows.

Adjourned at 9.45 P.M.

JOHN P. WENTWORTH, *Clerk.*

ANNUAL MEETING OF DESIGNERS SECTION.

BOSTON, March 9, 1921.— The annual meeting of the Designers' Section was held this evening in the Society Rooms, and was called to order by the Vice-Chairman, R. E. Rice, at 6.10 P.M. There were 31 members present.

The minutes of the previous meeting were read and approved. The report of the Executive Committee was read and accepted. The report of the Nominating Committee was then read, and, as instructed by vote, the Clerk cast one ballot for the officers nominated, as follows:

Chairman — Ralph E. Rice.
Vice-Chairman — Edwin S. Parker.
Clerk — Arthur L. Shaw.
Executive Committee —
Martin J. O'Brien.
Ernest D. Mortenson
Charles R. Berry

A letter from Chairman Ralph W. Horne, who was detained by illness, was read, in which he expressed his appreciation of the support of the members and officers during his administration.

The new Chairman, Ralph E. Rice, then assumed his office. He expressed his faith that the Section had made a real place for itself, and urged the coöperation of all to assure continued success. A vote of appreciation of the labors of the outgoing officers was passed.

The speaker of the evening, Prof. E. H. Rockwell, was then introduced, and discussed in an interesting and instructive manner, "Methods of Designing Rigid Concrete Frames."

At the conclusion of the talk a vote of thanks was extended to Professor Rockwell, and the meeting was adjourned at 7.45 P.M.

A. L. SHAW, *Clerk.*

ANNUAL REPORTS.

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1920–1921.

BOSTON, March 16, 1921.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 16, 1921.

Membership.

The total membership of the Society a year ago was 881, of whom 786 were members, 55 juniors, 7 honorary, 29 associate, and 4 were members of the Sanitary Section only.

During the year 24 members have resigned, 20 have forfeited membership for non-payment of dues, 3 juniors have lost membership because of age limit, and 10 have died, making total deductions of 57.

Seventy-six members in all grades have been added during the year, of whom 5 were former members reinstated, and 12 juniors and 1 associate have been transferred to the grade of member.

The present membership of the Society consists of 7 honorary members, 816 members, 43 juniors, 29 associates, and 5 who are members of the Sanitary Section only, making a total membership of 900.

Deaths.

The loss by death during the year has been 10, as follows:

Loammi F. Baldwin, May 10, 1920.
John R. Burke, April 27, 1920.
William M. Brown, May 28, 1920.
Louis B. Vaughan, July 23, 1920.
George S. Rice, December 7, 1920.
Edward A. Freeman, December 13, 1920.
Edmund M. Blake, January 12, 1921.
August F. Bildt, February 14, 1921.
James C. Scorgie, February 16, 1921.
David H. Andrews, February 24, 1921.

Remission of Dues.

Under authority of By-Law 8, the Board of Government has remitted the dues of 7 members.

Regular Meetings.

Nine regular meetings and one adjourned meeting have been held during the year, and a field day at Lake Suntaug, on June 9, in connection with the New England Water Works Association, took the place of the regular meeting that month.

The average attendance at these meetings was 166, the largest being 500 and the smallest 35.

At these meetings papers and addresses have been given, or special discussions held as follows:

March 17, 1920. — Address by the retiring President, Leonard Metcalf, "Constructive Effort *versus* Destructive Criticism and Inactivity in Professional Societies." Addresses on different phases of the Labor Problems by Hon. Frederick P. Fish, Mr. Richard H. Rice, of the General Electric Company, and Mr. Franklin T. Miller, of the F. W. Dodge Company, Boston.

April 21, 1920. — James W. Rollins, Past President, "Thames River Bridge" (illustrated).

May 19, 1920. — Prof. George W. Pierce, of Harvard University, "Submarine Detection and Acoustical Aids to Navigation" (illustrated with lantern slides).

September 15, 1920. — Dana M. Wood, "An Engineer's Impressions of Japan" (illustrated with lantern slides).

October 20, 1920. — "Wood and Concrete Piling," — an informal discussion by Charles R. Gow, James W. Rollins, Frank W. Hodgdon, Henry F. Bryant, J. Wright Taussig, John T. Scully, Frederick A. Waldron and Harry E. Sawtell.

November 17, 1920. — Past-President John R. Freeman, "Some Interesting Problems of China and the Far East" (illustrated with lantern slides).

December 17, 1920. — Joint meeting with the Boston Section of the American Society of Mechanical Engineers and the Boston Section of the American Institute of Electrical Engineers. Prof. Harold K. Barrows, "Water Power Development in New England" (illustrated). Henry I. Harriman, President of the New England Water-Power Company, "St. Lawrence Project."

This was the first of three joint meetings on hydro-electric development — the second being held January 18 under the auspices of the Boston Section of the American Institute of Electrical Engineers, with W. S. Murray speaking on "Electrical Features of the Super-Power Survey"; and the third, held on February 7, under the auspices of the Boston Section of the American Society of Mechanical Engineers, with W. M. White, of the Allis-Chalmers Company, speaking on "Recent Water-Wheel Developments and Settings," and E. B. Powell on the "Design of the Steam-Power Station for Hydraulic Relay."

January 26, 1921. — Roderick B. Young, C.E., senior assistant laboratory engineer, Hydro-Electric Power Commission, Ontario, "New Methods of Proportioning Concrete in Theory and Practice" (illustrated).

February 16, 1921. — William N. Connor, C.E., chief cost accountant, Aberthaw Construction Company, "Construction Costs" (illustrated with lantern slides).

At an adjourned meeting held on December 29, 1920, a discussion was had on the invitation received for the Society to join The Federated American Engineering Societies.

Sanitary Section Meetings.

The Sanitary Section has held six meetings and one excursion during the year. The following papers have been presented at the meetings of this Section:

March 3, 1920. — Col. Frank M. Gunby, "Living Conditions in the Orient."

October 6, 1920. — R. H. Eagles, "Treatment of Sewage and Trade Wastes by Mechanical Methods, with Special Reference to the Dorr Systems" (illustrated by the reflectoscope).

November 3, 1920. — Prof. George C. Whipple, "Recent Experiences in Europe."

November 10, 1920. — T. Chalkley Hatton, "Status of the Activated Sludge Plans at Milwaukee."

January 5, 1921. — Dr. L. L. Williams, "Rat Extermination and Proofing in Relation to the Prevention of Plague"; also discussions of the Report of the Special Plumbing Board of the Massachusetts Department of Health.

February 2, 1921. — Roy A. Lanphear, "Several Years' Experiments in the Treatment of Worcester Sewage."

The average attendance at the Sanitary Section meetings was 43.

On June 2, 1920, an excursion was made by the members of the Section to the Iron-Removal Plant of the Brookline Water Works, Brookline, Mass.

Designers Section.

As mentioned in the last annual report, the experiment of holding meetings by the younger members engaged in designing proved most satisfactory, and in answer to the petition signed by twenty-one members of the Society the Board on April 2, 1920, established the Designers Section.

On April 7 the first meeting was held, and on April 28 a code of by-laws was adopted and officers elected. The by-laws were approved by the Board, May 19, 1920.

Eight meetings have been held since the establishment of the Section, and at seven of these meetings technical subjects have been discussed.

The records of these meetings are as follows:

April 7, 1920. — B. A. Rich discussed "Small Concrete Highway Bridges."

April 28, 1920. — Meeting for election of officers and adoption of by-laws.

May 12, 1920. — Mark Linenthal spoke on "Concrete Ship Construction."

October 6, 1920. — Charles R. Gow and John T. Scully, "Borings; Practical Operation and Interpretation."

November 11, 1920. — J. Francis Travers, Jr., and John H. Hession discussed "Concrete Waterproofing."

December 8, 1920. — George A. Sherron, "Modern Concrete Road Construction: Machinery and Methods" (illustrated by slides and motion pictures).

January 12, 1921. — J. G. Rae discussed "Practical Design from the Contractor's Point of View."

February 9, 1921. — John R. Nichols discussed "Flat Slabs — Design and Building Codes."

The average attendance at these meetings has been 30.

The Designers Section is a proved success, and, with increasing appreciation of its possibilities, it will become a medium through which the Society can be of very definite value to the younger members.

Permanent Fund.

It was again found necessary to use some of the income of the Permanent Fund to meet current expenses, and by vote at the February meeting the entire income of the fund was appropriated and placed at the disposal of the Board for the payment of the expenses of the Society. Under this vote the sum of $2 371.48 has been appropriated, of which $1 543.18 has been expended for the current expenses of the past year.

Notwithstanding the appropriation of the entire income of the Permanent Fund, there has been added to the fund during the year the sum of $830.00. The present value of this fund is $44 682.51, and, with the E. K. Turner Fund, amounting to $1 097.12, the permanent funds of the Society amount to the sum of $45 779.63.

Cost of Journal.

The report of the Editor of the JOURNAL for the calendar year 1920 shows that ten issues of 1 250 copies each have been printed, comprising 625 pages. The net cost of the JOURNAL was $2 944.95, or $4.71 per page. In 1919 the net cost was $2 154.40, or $3.16 per page.

The very large increase in cost reflects the well-known conditions of 1920, during the early part of which costs of all kinds mounted to extreme levels, printing and paper keeping pace with these advances.

Award of the Desmond FitzGerald Medal.

In accordance with the recommendation of the committee appointed to consider the award of this medal for the best paper by a member of the Society published for the year ending September, 1920, the Board has awarded the medal to Harrison P. Eddy for his paper entitled, "Maximum Rates of Precipitation at Boston for Various Frequencies of Occurrence."

Licensing of Engineers.

A committee to investigate and report on the subject of licensing engineers was appointed May 19, 1920. This committee, realizing the necessity of coöperation, invited other societies to appoint representatives and make it a joint committee. Before final conclusions could be reached, the

American Association of Engineers introduced a bill into the Massachusetts legislature for the registration of engineers and land surveyors.

Believing that more consideration should be given to so important a question, the joint committee made a progress report to the Board of Government, recommending that the proposed legislation be opposed by the Society. While the Society did not adopt this recommendation, individual members, with representatives of other societies, appeared in overwhelming opposition at the hearing before the legislative committee, and the bill was referred to the next session of the General Court.

The Board recommends that the Committee on Licensing Engineers be continued.

The Federated American Engineering Societies.

In response to an invitation to join The Federated American Engineering Societies, a committee was appointed to consider and report on the advisability of such action. This committee recommended such affiliation if financially feasible, and at an adjourned meeting held December 29 called for the discussion of this subject; it was voted to be the sense of the meeting that the Society should join the Federation but that the annual dues should not be increased. At the regular meeting of January 26, similar action was voted and the matter referred to the membership for letter ballot. The result of this ballot, which has just been announced, is a vote of 322 in favor of and 37 against the Society becoming a member of the Federation.

Conservation of National Parks.

Following the constitutional provisions governing endorsements, the Society voted at the meeting of December 17, and subsequently by letter ballot (297 yeas, 10 nays), to endorse the proposed legislation amending the Federal Water-Power Act so as to make impossible entrance into National Parks for irrigation and water-power development and to oppose the so-called Smith Bill, granting rights in the National Parks.

Lease of Headquarters.

A new lease has been made of the Society rooms for the term of three years from October 1, 1920, and new leases have been made with our subtenants. Under the new lease the Society pays a gross yearly rental of $4 300, and after deducting the rentals paid by our tenants there is a net yearly increase in the Society's rent of $845, or 52%.

Coöperation with Other Societies.

At a meeting of the local members of the American Society of Civil Engineers on March 5, 1921, a committee was selected to consider the probable affiliation of a local section of the American Society, when formed, with this Society.

The committee on coöperation between Engineering Societies — referred to in the last annual report of the Board — has recommended the creation of a joint standing committee on coöperation, made up of representatives from all professional societies. It is believed that this is a step in the right direction and that the report should be referred to the incoming Board of Government with full powers.

Social Activities.

The luncheons served in the rooms of the Society before meetings have proved a success in the closer personal contact and sociability which results when men break bread together.

That these lunches have been provided is due to the capable planning and unselfish work of the Committee on Social Activities.

For the Board of Government,

F. A. Barbour, *President.*

Report of the Treasurer.

Boston, March 1, 1921.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year ending March 1, 1921.

Detailed data are contained in the appended tabular statements; Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; Table 3, investment of the Permanent Fund.

The current expenses for the year amount to $10 934.44, being $1 122.29 increase over the preceding year.

There has been transferred to the Current Fund, from income for current expenses carried over from last year, $927.45, also all the income of the Permanent Fund for the current year, amounting to $2 371.48, a total of $3 298.93, of which $828.30 remains unexpended.

The net expense of the Journal has been $658.38 more than last year. The income from advertisements decreased $130.44, otherwise the Journal expenses would show an increase of $527.94.

There has been an increase in the Permanent Fund of $830.00 after transferring the income for the current year of $2 371.48 to the Current Fund.

Ten coöperative bank shares have been withdrawn, valued at $1 742.30.

Respectfully submitted,

F. O. Whitney, *Treasurer.*

TABLE 1. — RECEIPTS AND EXPENDITURES.

CURRENT FUND.

Receipts.

Members' dues	$6 988.61
Advertisements	1 150.50
Sale of JOURNALS	278.22
Library fines	11.99
Old paper sold	7.04
June outing	18.87
Interest on bank deposits	8.58
Income fund for current expenses	927.45
Income from Permanent Fund	2 371.48
	$11 762.74

Expenditures.

JOURNAL		$4 472.22
Printing, stationery, postage, etc.		639.23
Rent (net)		2 205.40
Light		70.73
Salaries (except Editor)		2 421.00
Reporting		47.50
Stereopticon		27.50
Binding		149.25
Periodicals		79.45
Incidentals and repairs		278.94
Insurance		35.39
Annual meeting and dinner		292.45
Social activities		83.07
Sanitary Section, incidentals	$8.66	
Reporting	18.00	
Printing	54.15	
Stereopticon	12.00	
		92.81
Designers Section, incidentals	$2.00	
Printing	28.50	
Stereopticon	9.00	
		39.50
Balance		828.30
		$11 762.74

PERMANENT FUND.

Receipts.

Entrance fees	$700.00
Contributions	130.00
Interest received (net)	1 871.48
Coöperative bank shares withdrawn	1 742.30
	$4 443.78

Expenditures.

Coöperative bank dues	$900.00
Investments paid for	1 128.49
Transferred to Current Funds	2 371.48
Balance	43.81
	$4 443.78

E. K. TURNER LIBRARY FUND.

Cash on hand, March 1, 1920	$64.97
Interest on bond	50.00
	$114.97
Books purchased	$11.60
Cash	103.37
	$114.97

INCOME FOR CURRENT EXPENSES.

Cash on hand, March 1, 1920	$927.45
Transferred to Current Fund	$927.45

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.	March 1, 1918.	March 1, 1919.	March 1, 1920.	March 1, 1921.
Cash	$487.95	$487.12	$339.49	**$975.48**
Bonds and notes	34 835.00	35 023.00	35 523.00	**35 523.00**
Stock	1 950.00	1 950.00	1 950.00	**1 950.00**
Coöperative banks	5 930.85	7 179.65	8 501.75	**8 159.45**
Library	7 500.00	7 500.00	7 500.00	**7 500.00**
Furniture	2 405.11	2 405.11	2 405.11	**2 405.11**
	$53 099.91	$54 544.88	$56 213.35	**$56 513.04**
Liabilities.				
Permanent Fund	$41 687.92	$43 467.51	$43 852.51	**$44 682.51**
E. K. Turner Fund	1 023.12	1 063.22	1 058.72	**1 097.12**
Unexpended appropriations	105.92	.....	927.45	.....
Current funds	377.84	109.04	.....	**828.30**
Unpaid bills	.....	.....	469.56	.....
Surplus	9 905.11	9 905.11	9 905.11	**9 905.11**
	$53 099.91	$54 544.88	$56 213.35	**$56 513.04**

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 1, 1921.

Bonds.	Par Value.	Actual Cost.	Value as Carried on Books.
American Tel. & Tel. Co. Col. Tr. 4%, 1929.	$3 000.00	$2 328.75	$2 737.50
Union Elec. Light & Power Co. 5%, 1932...	2 000.00	2 050.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1939	2 000.00	1 995.00	1 995.00
Dayton Gas Co. 5%, 1930	2 000.00	2 000.00	2 000.00
Milford & Uxbridge St. Ry. 7%, 1923.....	3 000.00	2 942.50	2 942.50
Railway & Light Securities Co. 5%, 1939..	3 000.00	3 000.00	3 000.00
Superior Light & Power Co. 4%, 1931.....	4 000.00	3 547.50	3 347.50
Wheeling Electric Co. 5%, 1941	4 000.00	3 845.00	3 845.00
Economy Light & Power Co. 5%, 1956....	1 000.00	990.00	990.00
Tampa Electric Co. 5%, 1933	2 000.00	2 000.00	2 000.00
Galveston Houston Elec. Ry. Co. 5%, 1954	2 000.00	1 940.00	1 940.00
Northern Texas Elec. Co. 5%, 1940.....	2 000.00	1 932.50	1 932.50
Chicago & Northwestern Ry. 5%, 1987....	1 000.00	1 102.50	1 102.50
Vermont Power & Mfg. Co. 5%, 1928.....	1 000.00	965.00	965.00
American Tel. & Tel. Co. 5%, 1946.....	1 000.00	993.75	993.75
United States Liberty Loan 3½%, 1947....	2,000.00	2,000.00	2,000.00
American Tel. & Tel. Co. 6%, 1925	200.00	188.00	188.00
United States Victory Loan 4¾%, 1923...	500.00	500.00	500.00
	$35 700.00	$34 120.50	$34 529.25
Stock.			
15 shares Am. Tel. & Tel. Co.....	1 500.00	1 950.00	1 950.00
Total Securities.....	$37 200.00	$36 070.50	$36 479.25

Coöperative Banks.

25 shares Merchants Coöperative Bank, including interest to March.....	$3 194.25	
15 shares Volunteer Coöperative Bank, including interest to January.....	1 745.10	
25 shares Watertown Coöperative Bank, including interest to March.....	3 220.10	
		8 159.45
Total value of invested funds.....		$44 638.70
Cash.....		43.81
Total value of Permanent Funds.....		$44 682.51

E. K. Turner Fund.

	Par Value.	Actual Cost.		
Am. Tel. & Tel. Co. 5%, 1946	$1 000.00	$993.75	$993.75	
Cash on hand			103.37	
				1 097.12
				$45 779.63

We have examined the above report and found it correct.

STURGIS H. THORNDIKE,
HENRY B. WOOD,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

REPORT OF THE SECRETARY.

BOSTON, March 16, 1921.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS, *Dr.*

For cash received during the year ending March 16, 1921:

From entrance fees, new members and transfer:			
57 new members and associates	at $10,	$570.00	
14 juniors	at 5,	70.00	
12 juniors transferred to members	at 5,	60.00	
Total from entrance fees			$700.00
From annual dues for 1920–21, including dues from new members		$6 855.61	
From back dues		53.00	
From dues for 1921–22		80.00	
Total from dues			6 988.61
From rents			1 487.50
From advertisements			1 150.50
From sale of JOURNALS and reprints			278.22
From library fines			11.99
From sale of old paper			7.04
From Committee on Social Activities on account June outing			18.87
From contribution to building fund			100.00
From portion of donation to 25th Engineers, made February, 1918, and returned May, 1920			30.00
Total			$10 772.73

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

STURGIS H. THORNDIKE,
HENRY B. WOOD,
Auditing Committee of Directors of Boston Society of Civil Engineers.

Report of the Library Committee, 1920–21.

Boston, Mass., March 16, 1921.

To the Boston Society of Civil Engineers:

The Librarian submits for the Library Committee the following report for the year 1920–21.

Since the last report, 285 volumes bound in cloth and 279 bound in paper have been added to the library, making a total of 564 accessions.

There are now about 9 900 cloth-bound volumes in the library, and those bound in paper number about 3 279.

During the year 308 books have been loaned to members, and fines to the amount of $11.99 have been collected.

Rather more binding has been done this year than last, owing to the fact that the last half of the 1919 periodicals were added to this year on account of the illness and death of the assistant librarian.

The Society has received from the estate of Mr. F. L. Fuller the engineering books in his library, and while many of them were already on the shelves quite a number could be added to the library.

Thirteen books on engineering subjects have been added to Section 10, — two of them being purchased, four contributed by the authors and publishers, as follows: "Engineering for Land Drainage," by C. G. Elliott; "Railroad Curves and Earthworks," by C. Frank Allen; "Short-Span Bridges," by J. W. and E. D. Storrs; and "Power Development of Small Streams," by Harris and Rice. The other seven have been given by various members of the Society.

Clemens Herschel has contributed some thirty-seven volumes to the Herschel Library, as well as supplying "Annales des Ponts et Chaussees," volumes 1901–1919 inclusive, and "Zeitschrift für Bauwesen," volumes 1915–1919 inclusive, for binding.

The Catalogue Equipment and Supply Company have continued keeping up to date the collection of trade catalogues placed in our library, and pocket indexes to these catalogues will be furnished to members on request.

Respectfully submitted,

S. Everett Tinkham, *Librarian.*

Report of Executive Committee of the Sanitary Section.

Boston, Mass., March 2, 1921.

To the Sanitary Section, Boston Society of Civil Engineers:

Your Executive Committee presents the following report for the year 1920–21.

Six meetings have been held, the subjects and speakers being as follows:

March 3, 1920. — Annual meeting. "Living Conditions in the Orient." Col. Frank M. Gunby.

October 6, 1920. — "The Treatment of Sewage and Trade Wastes by Mechanical Methods, with Special Reference to the Dorr Systems." R. H. Eagles.

November 3, 1920. — "Recent Experiences in Europe." George C. Whipple.

November 10, 1920. — "The Status of the Activated Sludge Plans for Milwaukee." T. Chalkley Hatton.

January 5, 1921. — "Rat Extermination and Proofing in Its Relation to the Prevention of Plague." Dr. L. L. Williams.

Discussion of the Report of the Special Plumbing Board of the Massachusetts Department of Health.

February 2, 1921. — "Several Years' Experiments in the Treatment of Worcester Sewage." Roy S. Lanphear.

The average attendance at these meetings was 43.

On June 2, 1920, an excursion was made to the Iron-Removal Plant of the Brookline Water Works.

Membership. — Four new members have been added during the year, making a present total membership of 171.

Special Committees. — There are now three special committees in the Sanitary Section:

A committee on Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers.

A committee on Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water.

A committee on Proposed Rules and Regulations of the Special Plumbing Board.

It is recommended that these committees be continued for the coming year.

Respectfully submitted,
For the Executive Committee,

JOHN P. WENTWORTH, *Clerk.*

REPORT OF EXECUTIVE COMMITTEE OF THE DESIGNERS SECTION.

BOSTON, March 3, 1921.

To the Designers Section of the Boston Society of Civil Engineers:

The Designers Section has held eight meetings since its formal organization in the spring of 1920. At seven of these meetings technical subjects occupied the sessions. The second meeting was devoted to election of officers and adoption of a set of by-laws for submission to the Board of Government.

The speakers and subjects of the meetings are as follows:

April 7, 1920. — Mr. B. A. Rich, "Small Concrete Highway Bridges."
April 28, 1920. — Election of officers and adoption of by-laws.
May 12, 1920. — Mr. Mark Linenthal, "Concrete Ship Construction."
October 6, 1920. — Mr. Charles R. Gow and Mr. John T. Scully, "Borings."

November 11, 1920. — Mr. John H. Hession and Mr. J. Francis Travers, Jr., "Waterproofing."

December 8, 1920. — Mr. George A. Sherron, "Modern Concrete Road Construction: Machinery and Methods."

January 12, 1921. — Mr. J. G. Rae, "Practical Design from the Contractor's Point of View."

February 8, 1921. — Mr. John R. Nichols, "Flat Slabs; Design and Building Codes."

The attendance has steadily increased. There were 23 at the first meeting, April 7, 1920, and 40 at the last meeting on February 8, 1921. The average attendance was 30. The mailing list has contained but 50 names, and no concerted attempt has been made to swell the membership in the Section. It has been felt that the Section should justify its existence first upon a modest basis before undertaking to augment its enrollment by other than the voluntary applicants whom the Section's activities may have attracted. The experience of the past season has, your Executive Committee believes, demonstrated that the Designers Section fills a need among the younger members of the Society, and it is therefore recommended that the incoming officials consider the popularization of the Section, making an effort to acquaint the members of the Society with its activities, so that a greater number may receive its benefits.

It is further recommended that it be made the custom of the Section to formally close all sessions promptly at 7.45 P.M., so that advantage of the 6.00 P.M. opening hour may not be lost for those who desire it. This can probably be done without preventing the continuation of the discussions informally by all who wish.

A revival of the plan — adopted in an earlier meeting, but fallen into disuse — to have each member when he rises to speak during a discussion give his name and that of the firm by whom he is employed, is recommended.

Respectfully submitted,
For the Executive Committee, by
A. L. Shaw, *Clerk.*

Report of Committee on Social Activities.

Boston, Mass., March 16, 1921.

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits this annual report for the year 1920–21.

At the annual smoker held on March 17, 1920, this committee was requested to provide the entertainment for the evening. The committee secured the services of an orchestra, which furnished selections during the evening; Jack Liden, who came with a good supply of stories and anecdotes; the Apollo Male Quartet, who furnished vocal selections very acceptably, and moving pictures of educational subjects. On account of the meeting coming on March 17, the committee provided green decorated crêpe paper hats, which were worn by every one present. Judging from the interest and enthusiasm shown, we are led to believe that every one present enjoyed himself.

Shortly after the annual meeting, the committee, in conjunction with a committee from the New England Water Works Association, began looking for a suitable place for the outing. Many amusement parks and resorts were discussed, and Wardhurst on Lake Suntaug in Lynnfield was selected as the most desirable. On June 9 the two societies visited Wardhurst for the annual outing and field day. The day was beautiful, the proprietor very cordial, everybody happy, and all the 109 present agreed on its success. Track events for gentlemen and ladies were run off in the morning, and after a most enjoyable dinner a red-hot baseball game was played between the Boston Society of Civil Engineers and the New England Water Works Association, the Boston Society team being the victors.

Previous to each of the regular monthly meetings, with one exception, the social hour has been held, beginning at 6.15 P.M. and filling in the time when some of the members would ordinarily go home and be too comfortable to come back to the meeting. At each of these occasions light refreshments were served, and men touched elbows with each other and became better acquainted. The exception was in December, when a large joint meeting was held and we had no data whatever as to how many to provide for.

The membership of the Society has increased, men know each other better, and the committee feels that this social hour has been a success.

The committee has been asked to take charge of the "smoker" and entertainment, in connection with the President and Secretary.

The chairman wishes to acknowledge the hearty coöperation and help of the committee, without whose assistance these activities could not have been a success.

Respectfully submitted,

CHARLES R. BERRY,
Chairman of Committee on Social Activities.

REPORT OF COMMITTEE ON LICENSING ENGINEERS.

BOSTON, MASS., March 12, 1921.

TO THE BOARD OF GOVERNMENT, BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — The undersigned committee of members of the Boston Society of Civil Engineers, appointed by your Board to consider the matter of licensing of engineers, begs to submit the following report.

The committee refers to the majority report of the joint committee on licensing of engineers, composed of this committee and representatives of other engineering and architectural societies, submitted to your Board under date of January 8, 1921, as signed by twelve of the thirteen members of that committee, and states that the American Association of Engineers did not withdraw its petition to the legislature with its accompanying bill for the registration of professional engineers and land surveyors, as recommended in the aforesaid report that it be requested to do.

The members of the majority of the joint committee then voted to oppose the bill as individuals and to be represented by counsel.

A hearing on the bill was held by the legislative committee on mercantile affairs on February 18, 1921. The bill was favored by counsel for the American Association of Engineers, and the speakers in favor of the bill were only those introduced by him and who are understood to be members of that society.

Both the form of the bill and the principle of registration were opposed or questioned in person, by counsel or by letter, by members of the seven other societies represented on the joint committee, as well as by members of the American Chemical Society, the Engineering Society of Western Massachusetts and individual engineers. A count of those present, by the legislative committee, showed 19 in favor, against 89 opposed.

The legislative committee recommended the bill be referred to the next annual session of the legislature, and this recommendation was adopted in the Senate on February 24, 1921, and by the House on March 3.

The undersigned committee recommends that it or a similar committee be continued during the coming year to further study the matter of licensing engineers, and that your Board at its discretion invite other engineering or architectural societies to add their representatives to its membership and so continue a joint committee on the licensing of architects and engineers,

Respectfully submitted,

(Signed) Charles W. Sherman.
Charles R. Gow
Charles T. Ma[illegible]
Charles M. Sp[illegible]ord.
Irving E. Moul[illegible]op.
Edwin H. Rogers, *Chairman.*

Report of the Editor.

To the Board of Government, Boston Society of Civil Engineers:

Gentlemen, — The Editor submits the following report for the calendar year 1920.

There have been published 13 papers and 10 memoirs of deceased members.

The 10 issues of the Journal, of 1 250 copies each, contained a total of 625 pages.

The net cost was $2 944.95, or $4.71 per page. In 1919 the net cost was $2 154.40, or $3.16 per page. The very large increase in cost reflects the well-known conditions of 1920, during the early part of which costs of all kinds mounted to extreme levels. Printing and paper kept pace with these advances.

There are indications, in addition to those given by the general situation, that before the middle of 1921 the cost of the Journal will have commenced to decline from the present high level.

In the appended table are shown in tabular form figures of cost, number of pages, and other details.

Respectfully submitted,

W. L. Butcher, *Editor.*

Month.	PAGES OF				NO. OF		COST OF							
	Papers.	Proc.	Index.	Adv. (inc. Index and Other Unpaid Space).	Inserts.	Cuts.	Papers, Proc. and Index (inc. Stock for Adv. Pages).	Inserts and Cuts.†	Adv.	Reprints.	Postage, Wrapping and Mailing.	Editing.	Incidentals.	Copyright.
Jan.	46	4		19 5/6		1	$263.69	$4.84	$24.25		$22.12			
Feb.	36	8		19 5/6	1	5	303.47	66.44	36.82	$35.00	27.83		$5.00	
Mar.	16	14		19 1/2		3	184.78	11.58	40.50	15.00	25.83			
Apr.	58	24		19 1/2		7	446.31	17.49	43.63	60.00	22.55			
May	20	16		19 1/2		3	222.86	21.64	27.25	15.50	24.95		5.06	
June	26	14		19 1/2		17	234.89	77.55	31.88	25.00	26.55		.14	
Sept.	28	8		18 1/4	1	1	244.13	45.02	21.00	33.40	25.16		72.86	
Oct.	14	10		18 1/4			193.06		39.50		29.48		5.00	
Nov.	28	8		18 1/4		5	261.82		51.45	47.00	22.79			
Dec.	27	12	8	18 1/4		1	341.79	4.44	31.50		27.97		4.40	
Totals	299	118	8	189 1/3*	2	43	$2 696.80	$249.00	$347.78	$230.90	$255.23	$450.00	$92.46‡	$10.00

* 200 pages used, not all set solid.

† Some cuts supplied by authors.

‡ Includes $72.50 for wrappers for mailing purposes and $15 second-class postage.

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APPLICATIONS FOR MEMBERSHIP.

[April 15, 1921.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Abbott, Henry Kingman, Reading, Mass. (Age 28, b. Reading, Mass.) High school education. In 1913 entered the employ of C. E. Carter as rodman, working up to chief of party; joined the army in 1918; from Mar. to Aug., 1919, was chief of party for Weston & Sampson at U. S. Housing Corps' project; from Sept., 1919, to June, 1920, with F. E. Sherry, C.E.; from June to Sept., 1920, inspector on sewer work at Reading, Mass.; and from Sept., 1920, to present time, with Dana F. Perkins, Reading, Mass. Refers to F. A. Barbour, C. E. Carter, H. F. Davis, F. W. Haley and G. A. Sampson.

Brosnahan, John E., Boston, Mass. (Age 28, b. Boston, Mass.) Educated in Boston public schools, and engineering courses in various night schools, also three years' private instruction in engineering. From Feb., 1912, to the present time, rodman and instrumentman with the Sewer Service, City of Boston. Refers to T. F. Bowes, F. W. Dakin, E. S. Dorr, C. S. Drake, J. E. L. Monaghan and E. F. Murphy.

Currier, George Washington, Brighton, Mass. (Age 61, b. Lawrence, Mass.) Educated in the Lawrence High School, two and a half years at Amherst College, and four years at Harvard Medical School. In 1900 employed as draftsman in the Sewer Service, City of Boston; 1901–14, reporter, editor and artist on Boston newspapers; 1914–17, senior draftsman in Sewer Division, City of Boston; transferred in 1917 to the Bridge and Ferry Division of City of Boston, where he is now employed as a designing draftsman. Refers

to J. E. Carty, E. S. Dorr, C. S. Drake, J. E. L. Monaghan, L. B. Reilly and S. E. Tinkham.

Davidson, William F., Clinton, Mass. (Age 33, b. Clinton, Mass.) From 1905–1916 in the employ of Parker, Bateman & Chase, civil engineers; from April, 1916, to May, 1918, superintendent of streets, town of Lancaster; from May, 1918, to July, 1919, with Engineers, U. S. Army; from July, 1919, to April, 1920, again superintendent of streets of Lancaster; from April, 1920, to date, engineer and superintendent of streets and sewers of town of Clinton. Refers to E. R. B. Allardice, F. W. Bateman, L. H. Bateman and G. H. Chase.

Dufour, Frank Oliver, Newtonville, Mass. (Age 48, b. Washington, D. C.) Is an associate member of the American Society of Civil Engineers. At present structural engineer with Stone & Webster, Inc. Refers to F. A. Barbour, F. M. Gunby, C. T. Main, H. E. Sawtell and S. E. Tinkham.

Gianni, Placido, Boston, Mass. (Age 22, b. Palermo, Italy.) Student in carpentry and building at Boston Trade School, 1914–16, and at Wentworth Institute, in architecture and civil engineering, 1916–19. From July, 1919, to March, 1920, drafting and designing concrete buildings with Kearns Construction Co.; March to Sept., 1920, drafting and designing concrete buildings with Nordyke C. Marmon Co., Indianapolis, Ind., and from Sept., 1920, to date, draftsman with the Swett & Sibley Co., ornamental iron and wire workers, Cambridge. Refers to A. G. Martin, E. P. Rankin, H. C. Thomas and E. A. Varney.

O'Connell, Timothy J., Boston, Mass. (Age 40, b. Somerville, Mass.) Educated in Dorchester High School and English High School (evenings). From 1900 to 1905, superintendent, D. F. O'Connell Co.; from 1905 to 1912, member of firm of T. J. O'Connell; and from 1912 to date, member of firm and manager, William Barrett & Co. Refers to E. S. Dorr, C. S. Drake, F. A. Garvin, J. E. L. Monaghan and E. F. Murphy.

Ryan, Edward James, Boston, Mass. (Age 37, b. Boston, Mass.) Educated in Boston public schools. From 1906 to 1912, rodman in Sewer Service of City of Boston; from 1912 to 1917, transitman in same service, in charge of party on sewer surveys and construction; from 1917 to 1920, supervisor catch-basin cleaning contracts; and from 1920 to date, engineering representative in charge of inspecting and distribution of iron castings for Sewer Service. Refers to T. F. Bowes, J. E. Carty, E. S. Dorr, C. S. Drake, E. F. Murphy and J. E. L. Monaghan.

Sullivan, Daniel Maynard, Boston, Mass. (Age 33, b. Newport, R. I.) Graduate of Tufts College, 1911, with degree of B.S. in engineering. Summers of 1910 and 1911, topographical aid, U. S. Geological Survey, and from 1911 to date, employed in Public Works Department, Boston, as follows: 1911–12 as rodman; 1912–16 as instrumentman; 1916–18 as junior engineer, and 1918–21 as assistant engineer in charge of construction of high-pressure fire service. Refers to C. J. Carven, E. S. Dorr, C. S. Drake, F. A. McInnes, J. E. L. Monaghan and E. F. Murphy.

VAUGHAN, JOHN FAIRFIELD, Cambridge, Mass. (Age 49, b. Cambridge, Mass.) Graduate of Harvard University, with degree of S.B., in 1895. From 1895 to 1896, with General Electric Co., in construction work of electrification of N. Y., N. H. & H. R. R.; from 1896 to 1902, engineer for electrical department of N. Y., N. Y. & H. R. R., in charge of design, construction and operation of electrification; from 1902 to 1916, with Stone & Webster, Inc., as engineer, head of railway and hydraulic department, and consultant from 1916 to 1917; private practice to date, office continuing through absence in war work in charge of assistant; from 1917 to 1919, supervisor, U. S. S. B., Emergency Fleet Corp., Division Wood Ship Construction, and district manager, same corporation, and in 1919 returned to own office. Refers to C. T. Main, S. H. Thorndike, D. M. Wood and J. R. Worcester.

LIST OF MEMBERS.

ADDITIONS.

ALLEN, HERBERT B. ..... 154 Harrison Ave., Fitchburg, Mass.
BOYD, WALTER E. ..... 67 River St., Hudson, Mass.
BURRAGE, HENRY T. ..... 15 Ellery St., Cambridge 38, Mass.
CONNOR, JOHN E. ..... 703 City Hall Annex, Boston 9, Mass.
COVE, EARLE H. ..... 80 Sprague St., Readville, Mass.
CRONIN, WILLIAM H. ..... 361 Washington St., Cambridge, Mass.
GARVIN, FRANK A. ..... 67 Fairbanks St., Brighton 35, Mass.
HAGGERTY, THOMAS J. ..... 111 Union Park St., Boston 18, Mass.
HORGAN, J. J. ..... 931 River St., Fitchburg, Mass.
LELAND, FRANKLIN E. ..... 25 Groveland St., Auburndale, Mass.
MACLEAY, FRANCIS R. ..... Goddard Seminary, Barre, Vt.
NORRIS, CLARENCE G. ..... 217 Fairmount Ave., Hyde Park 36, Mass.
SHAW, PERCY A. ..... 11 W. Appleton St., Manchester, N. H.
SULLIVAN, THOMAS F. ..... 1736 Columbia Road, So. Boston, Mass.
WATSON, GEORGE N. ..... 137 Edenfield Ave., Watertown, Mass.

CHANGES OF ADDRESS.

ALLEN, CHESTER S. ..... 60 Federal St., Boston, Mass.
ALBEE, E. E. ..... 46 Harbor View Ave., Winthrop 52, Mass.
BABBITT, JOHN H. ..... Room 38, Y. M. C. A., New Castle, Pa.
BROWN, ALBERT F. ..... 36 Maxwell St., Boston 24, Mass.
CARSON, HOWARD A. ..... Mango Ave. Hotel, Sarasota, Fla.
CLARKSON, EDWARD H., Jr. ..... 41 Tyng St., Newburyport, Mass.
EWING, W. C. ..... American City Bureau, Tribune Bldg., New York, N. Y.
GOULD, GARDNER S. ..... 33 Rhodes Ave., Edgewood, R. I.
HALE, RICHARD K. ..... 559 Chestnut Hill Ave., Brookline, Mass.
HOLMES, H. E. ..... 5 Arlington Terrace, Malden, Mass.
HOLWAY, WILLIAM R. ..... 1616 So. Forest St., Tulsa, Okla.
LINENTHAL, MARK ..... Room 810, 43 Tremont St., Boston 9, Mass.

LEWIS, GEORGE W.....Wayland, Mass.
LOVEJOY, FREDERICK A.....703 City Hall Annex, Boston 9, Mass.
MELLISH, MURRAY H... Care of J. G. White Engrg. Corp., 43 Exchange Pl., New York, N. Y.
NEGUS, ARTHUR I.....173 Cabot St., Holyoke, Mass.
NOLAN, CONRAD.....P. O. Box 43, Jacksonville, Fla.
PHILLIPS, LAURENCE J.....Room 1021, 100 Boylston St., Boston, Mass.
SHAW, EDWARD W.....482 California St., Newtonville, Mass.
SKILLIN, FRED. B.....37 Burnside Ave., W. Somerville 44, Mass.
STEARNS, GEORGE H.....145 Kent St., Brookline, Mass.
STENBERG, THORNTON R.....Box 531, Atlanta, Ga.
SYLVIA, MANUEL H...Rio de Janeiro & Sao Paulo Telephone Co., rue Libero Badaro N. 52, Sao Paulo, Brazil, So. America
WEBB, GEORGE F.....244 Peoples St., Atlanta, Ga.
WHITNEY, HARRY L.....38 Wallace St., W. Somerville 44, Mass.

RESIGNATIONS.

BARNEY, HAROLD B.
BARRUS, GEORGE H.
BURPEE, MOSES.
FIELDING, WILLIAM J.
GAUTHIER, ALMON I.
HOLMES, ALBERT J.
HUBBARD, CARL P.
LINCOLN, JAMES G.
MURPHY, EDWARD T.
NASH, PHILIP C.
REYNOLDS, HENRY J.
SANBORN, FRANK B.
SAWYER, GEORGE S.
SUMNER, MERTON R.
TINKHAM, CHARLES S.
WOOD, FREDERICK J.

EMPLOYMENT BUREAU.

THE Board of Government has established an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

No. 535. Age 28. Graduate Washington Academy (Maine) and Pratt Institute, Brooklyn, N. Y. Four years' experience in electrical laboratories with reference to fire hazards, two years as inspector of wire and cables. Desires position as inspector of wire and cable, or construction work for which education and training has fitted.

No. 537. Age 31. Graduate of Tufts College, in civil engineering, in 1912. Four years' experience as instrumentman, two years and a half inspecting, drafting and designing steel and concrete bridges and buildings. Desires evening work, drafting, estimating or checking.

No. 538. Age 30. Graduate of Dartmouth, 1913, with degree of B.S., and from Mass. Institution of Technology, 1915, in sanitary engineering. Experience as engineer's assistant and timekeeper, one year; one year as sanitary inspector; one year as chief of party on surveys, graded streets, sewers; one year as assistant at Army Base on progress reports and computations; and two years as inspector and supervisor of construction. Salary desired, $175 a month.

No. 539. Age 44. Graduate of Lawrence Scientific School and Harvard University. Member of American Society of Civil Engineers. Over twenty years' varied experience as engineer on structural work, industrial engineering, specification work and estimating. Interviews desired.

No. 540. Age 42. Technical High School education. Experience as chief estimator six and a half years; chief estimator and cost man for two years. Desires position as estimator. Salary desired, $40 per week.

No. 541. Age 55. College education. Member American Society of Civil Engineers. Wide experience in construction work, railroad, mills, bridges, water works, sewers, dams, etc.

No. 542. Age 23. General engineering experience covering a period of six years, both in surveying and construction. Desires position as resident engineer, chief of party or transitman.

No. 543. Age 33. Graduate of Worcester Polytechnic Institute. Has had four years on electrical and heating work, and four years on electrical engineering and building equipment. Desires a position as executive or assistant engineer.

No. 544. Age 22. High-school education and two years at college. Has had experience as rodman and transitman. Desires position as rodman ($20 per week) or transitman ($25 per week).

No. 545. Age 25. Technical education. Has had two years' experience supervising construction and two years' designing reinforced concrete, steel and mill construction; architectural drafting, detailing and quantity estimating. Desires position as office or construction engineer. Salary desired, $45 per week.

No. 546. Age 38. Technical education. Has had long experience, as draftsman, designer and assistant superintendent on special machinery, also as production engineer investigating production losses, etc. Desires position as chief draftsman or production engineer. Salary desired, $2 500 and $3 000 a year, respectively.

No. 547. Age 27. Graduate of Mass. Institute of Technology in civil engineering. Has had experience in planning and scheduling of jobs, in addition to instrument work; has also had experience in concrete form design. Desires position as engineer or assistant superintendent on reinforced concrete, or would accept office position as planner. Salary desired, $2 500 a year.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Bulletin No. 931, U. S. Department of Agriculture.
Cotton Production and Distribution. 1919–20.
Results of Observations near Honolulu, Hawaii. 1917–18.
Results of Observations at Sitka, Alaska, 1917–18.
Water-Supply Papers, Nos. 415, 424, 434, 451, 454, 474, 456.

State Reports.

Illinois. Inland Waterways and Transportation Costs. Mortimer G. Barnes.

Massachusetts. Annual Report Public Service Commission. 1919.

Massachusetts. Annual Report State Department of Health. 1919.

Massachusetts. Investigations upon Purification of Sewage and Water at Lawrence Experiment Station. 1918 and 1919.

New Hampshire. Biennial Report, State Highway Department. 1918–20.

New York. Report Public Service Commission. Vol. 1. 1917.

New York. Report Public Service Commission. Vol. 1. 1918.

New York. Report Public Service Commission. Appendix to Vol. 1. 1915.

County Reports.

Essex County, Mass. Engineer's Report. 1920.

City and Town Reports.

Boston, Mass. Annual Report, Public Works Department. 1919.

Bridgeton, N. J. Report on Municipal Refuse Collection and Disposal. 1920.

Brookline, Mass. Annual Report of Water Board. 1920.

Cambridge, Mass. Annual Report of Water Department. 1919–20.

Cambridge, Mass. Annual Reports of City Engineer. 1918 and 1919.

Dover, N. H. Annual Report of Board of Water Commissioners. 1920.

Framingham, Mass. Annual Report of Board of Public Works. 1920.

Holyoke, Mass. Annual Report Board of Water Commissioners. 1920.

Providence, R. I. Annual Report Department of Public Works. 1920.

Reading, Mass. Annual Report of Water Commissioners. 1920.

Rutland, Vt. Annual City Report. 1920.

Miscellaneous.

Fire Tests of Building Columns. National Board of Fire Underwriters.

Maine Book, The. By State Librarian. Gift of H. S. Knowlton.

Mineral Productions of Canada. 1919 and 1920.

Proceedings of Institution of Civil Engineers. (Lond.) Vol. 207.

Public Health Work of Professor Sedgwick. Geo. C. Whipple.

LIBRARY COMMITTEE.

Vol. VIII MAY, 1921 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Construction Costs." By W. N. Connor.
Memoir of Deceased Member.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, April 20, 1921. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Robert Spurr Weston.

There were 34 members and visitors present.

The President stated that, owing to illness, the Secretary would be unable to be present. Professor Spofford moved that Mr. F. I. Winslow act as Secretary *pro tem.*, and, on his declining, Mr. J. L. Howard was elected as Secretary *pro tem.*

The President gave an informal account of the meeting of the American Engineering Council held in Philadelphia.

Mr. F. I. Winslow offered the following motion:

"*Moved*: That any member of this Society who has paid the dues assessed to him for forty years shall thereafter be exempt from the payment of all dues to the Society."

On motion of Professor Spofford, the motion was amended to be referred to the Board of Government.

The President then introduced Mr. Walter E. Spear, a member of the Society, who presented a very interesting paper on the "Public Works in Modern Greece," dealing with the proposition for a water supply for Athens and Piræus, illustrated with numerous lantern slides.

After questions and discussions by Messrs. Spofford, Armstrong, Gunby and Weston, a vote of thanks was passed Mr. Spear.

The meeting adjourned at 9.30 P.M.

J. L. HOWARD,
Secretary pro tem.

APPLICATIONS FOR MEMBERSHIP.

[May 15, 1921.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

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The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

KENT, ROBERT WILLARD, Newton Centre, Mass. (Age 31, b. Woonsocket, R. I.) Educated in the Woonsocket High School and Rhode Island State College, graduating in 1911 with a degree of B.S. Employed in summer vacations as follows: 1908, assistant to Master Mechanic, Manville Co.,

Woonsocket, R. I.; 1909, in United States Engineer Corps, at Newport, R. I.; 1910–11, Newport Water Works; since graduation spent three months with T. G. Hazard, Jr.; from November, 1911, to November, 1913, engineer for Fore River Ship Building Corp., Quincy, Mass.; November, 1913, to March, 1914, engineer for Newport News Shipbuilding & Dry Dock Co.; March, 1914, to October, 1916, engineer for F. A. Sayles Industrial Interests, Pawtucket, R. I.; October, 1916, to August, 1917, industrial and construction engineer for Cooley & Marvin Co., Boston; August, 1917, to February, 1919, 1st Lieutenant Ordnance Department, U.S.A.; February, 1919, to the present, construction engineer, Cooley & Marvin Co., Boston. Refers to T. G. Hazard, Jr., W. Kent, F. H. Mills, A. J. Ober, C. F. Parker, R. F. Rhodes and A. Seagrave.

Mulcare, Thomas, Cambridge, Mass. (Age 34, b. North Adams, Mass.) Graduate of University of Vermont with a degree of B.S. in civil engineering. From July, 1909, to March, 1910, with the Springfield Water Department on the construction of Borden Brook Dam; from March, 1910, to September, 1910, with the Pittsburg Contracting Co. on the Catskill Aqueduct construction; September, 1910, to April, 1911, with the N. Y. C. & H. R. R. on electrical zone work at Yonkers, N. Y.; April, 1911, to February, 1912, with the Grand Trunk Pacific R. R. as resident engineer on the Regina-Moose Jaw Branch; from February, 1912, to August, 1913, and from June, 1914, to October, 1915, in the contracting business in North Adams; from August, 1913, to June, 1914, and from October, 1915, to February, 1917, with the Public Service Commission on New York City subway construction; from February, 1917, to March, 1921, with the Turner Construction Co. as superintendent, and at present in the contracting business. Refers to T. M. Beach, E. E. Lochridge, J. J. Rourke and A. G. Tomasello.

Newsom, Reeves J., Lynn, Mass. (Age 27, b. Columbus, Ind.) Graduated from Purdue University in 1913, followed by one year at Mass. Inst. of Tech. From May, 1914, to July, 1916, was resident engineer, Lynn Additional Water Supply; July, 1916, to January, 1918, superintendent of Water Works, Lynn. Refers to H. K. Barrows, C. B. Breed, L. Metcalf and W. L. Vennard.

Valdes, Viviano L., Boston, Mass. (Age 20, b. Monterey, Mexico.) Attended a preparatory school in Monterey, Mexico, 1913–1916; spent one year at the University of Notre Dame, and entered Mass. Inst. of Tech. in the fall of 1917. Refers to J. B. Babcock, G. L. Hosmer, A. P. Porter, D. Porter, K. C. Reynolds, and C. Hale Sutherland.

LIST OF MEMBERS.

ADDITIONS.

Bryant, George L. . . . . 231 Lamartine St., Jamaica Plain, Mass.
Conger, Alger A. . . . . 35 Harvard St., Worcester, Mass.
Connor, Bernard D. . . . . 77 Pennsylvania Ave., Somerville, Mass.
Mueser, William H. . . . . 73 Mountfort St., Boston 17, Mass.

CHANGES OF ADDRESS.

BROWN, T. MORRIS.....38 No. Burnett St., E. Orange, N. J.
CLAPP, WILFRED A.....Care Post Quartermaster, Ft. Sheridan, Ill.
GAVETT, ANDREW J.....312 West 5th St., Plainfield, N. J.
HORTON, FREEMAN H.....Bradentown, Fla.
KILLION, LOUIS J.....50 East 42d St., New York, N. Y.
KIRKPATRICK, CHARLES D.....79 Milk St., Boston, Mass.
LEAVITT, ALBERT J.....105 Warren Ave., Hyde Park, Mass.
RICH, MALCOLM.....316 Broadway, New York, N. Y.
STEARNS, RALPH H.....10th Floor, 14 Wood St., Pittsburg, Pa.
WRIGHT, FRANK V.....197 Forest St., Arlington, Mass.

DEATHS

MONAGHAN, JOHN F.....April 18, 1921
TINKHAM, S. EVERETT.....April 21, 1921

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Birth Statistics. United States Bureau of Census. 1919.

Black Walnut, Its Growth and Management. F. S. Baker.

Financial Statistics of Cities. 1919.

Mineral Resources of United States. 1917. Part 1. Metals.

Reconstruction and Production. Report No. 829.

Study of California Highway System. United States Bureau of Public Roads.

Water Supply Papers Nos. 447 and 449.

State Reports.

Connecticut. Report of the Public Utilities Commission. 1920.

Massachusetts. Industrial Review, No. 4 Department of Labor and Industries.

Maine. Report of Maine Water Power Commission. 1920.

New Hampshire. Report of Public Service Commission. September, 1916, to August, 1918.

Municipal Reports.

Brockton, Mass. Annual Reports of Water Commissioners. 1919 and 1920.

Burlington, Vt. Annual Report Water Department. 1920.

Cambridge, Mass. Origin and History of Streets.

Danvers, Mass. Annual Report of Water Commissioners. 1920.

New Bedford, Mass. Annual Report of Water Board. 1920.

Plymouth, Mass. Annual report of Water Commissioners. 1920.

Reading, Pa. Annual Report Bureau of Water. 1919.

San Francisco, Cal. Hetch Hetchy Water Supply. Report of J. R. Freeman. 1912. Gift of Stone & Webster's library.

San Francisco, Cal. Future Water Supply. Report of Spring Valley Water Company. 1912.

Miscellaneous.

Book of Plans, New York State Barge Canal. Gift of Clemens Herschel.

Geographic Tables and Formulas. S. S. Gannett. Gift of H. B. Wood.

Hydraulics of the Miami Flood Control Project. Part 7. Sherman M. Woodward.

Location, Grading and Drainage of Highways. Wilson G. Harger. Gift of McGraw-Hill Book Co.

Production of Coal and Coke in Canada. 1919.

Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and Other Metals in Canada. 1919.

LIBRARY COMMITTEE.

Vol. VIII JUNE, 1921 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"The Public Works of Modern Greece." Walter E. Spear.
Memoirs of deceased members.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, May 18, 1921. — A regular meeting of the Boston Society of Civil Engineers was held this evening at the Society Rooms, Tremont Temple, and was called to order at 7.45 o'clock by the President, Robert Spurr Weston.

There being no quorum, Mr. Dorr moved, and it was duly seconded, that the meeting adjourn to Wednesday, May 25, at Chipman Hall, at 7.45 P.M. On a vote being taken, this motion was carried.

RICHARD K. HALE,
Acting Secretary.

BOSTON, May 25, 1921. — An adjourned meeting of the Boston Society of Civil Engineers was held this evening in Lorimer Hall, Tremont Temple, The meeting was called to order at 7.45 o'clock by the President, Robert Spurr Weston.

There were fifty members and visitors present.

The President presented the report of the Board of Government on the affiliation of the proposed Northwestern Section of the American Society of Civil Engineers with the Boston Society of Civil Engineers. On motion of Mr. Main, it was

Voted: That the report of the Board of Government on the affiliation of the proposed local section of the American Society of Civil Engineers with the Boston Society of Civil Engineers be accepted and its recommendations adopted.

The President then introduced Mr. Desmond FitzGerald, who presented a most interesting paper, entitled "Something about the Canyons of Utah." The paper was illustrated with a number of beautifully colored lantern slides.

The President announced the death of John F. Monaghan on April 18, 1921. Mr. Monaghan has been a member of the Society since January 27, 1909.

The President presented the memoir of David H. Andrews, prepared by John C. Moses and J. Parker Snow; the memoir of James C. Scorgie, prepared by John V. Peterson, and that of Louis B. Vaughan, prepared by F. E. Winsor. These memoirs were accepted and ordered to be printed in the JOURNAL.

Adjourned at 9.00 o'clock.

RICHARD K. HALE,
Acting Secretary.

REPORT ON THE AFFILIATION OF THE PROPOSED "NORTHEASTERN SECTION" OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS WITH THE BOSTON SOCIETY OF CIVIL ENGINEERS.

The members of the American Society of Civil Engineers in this territory are organizing a Section of that Society, to be known as the "NORTHEASTERN SECTION." At a meeting called for the purpose of considering its organization, at which about sixty were present, a committee was appointed to see if the proposed Section might be affiliated with the Boston Society of Civil Engineers.

This committee consisted of three who were members of the American Society of Civil Engineers only, and three who were also members of the Boston Society of Civil Engineers.

After careful consideration and an informal discussion with the members of the Board of Government of the Boston Society, this committee reported in favor of such affiliation as follows:

To the Local Members of the
American Society of Civil Engineers:

The undersigned Committee selected to consider and report on the feasibility of affiliating the proposed local Section of the American Society of Civil Engineers with the Boston Society of Civil Engineers respectfully submits the result of its deliberations.

We are unanimously of the opinion that affiliation is both desirable and practicable, and we recommend that it be effected in the following manner:

(1) "That the local Section of the American Society of Civil Engineers be affiliated with the Boston Society of Civil Engineers; that, as a part of the Boston Society of Civil Engineers it shall be known as the American Society of Civil Engineers Section of the Boston Society of Civil Engineers, and also that, as a local section of the American Society of Civil Engineers, it may be known as the Northeastern Section of the American Society of Civil Engineers, the New England Section, or any other name which may be chosen and approved by the parent American Society.

(2) "That the B. S. C. E. grant to the members of the Am. Soc. C. E. Section all rights and privileges accruing to full membership in the B. S. C. E., except the rights to vote, to hold office and to receive the JOURNAL.

(3) "That the dues of the Am. Soc. C. E. Section shall be, for those who are not members of the B. S. C. E., Five Dollars per year for resident, and Three Dollars per year for non-resident, members; for those who are members of the B. S. C. E. there shall be no dues.

(4) "That the Am. Soc. C. E. Section shall pay yearly to the B. S. C. E. the sum of Five Dollars for resident and Three Dollars for non-resident Section members who are not members of the B. S. C. E.; and in addition thereto the Section shall pay yearly to the B. S. C. E., for each and every one of its members of any class, an amount equal to the per capita allowance made to the local Section by the parent Am. Soc. C. E."

By the foregoing plan, the Boston Society of Civil Engineers would undertake to furnish the use of its rooms and library, the services of its secretarial assistants, to do all printing and mailing of notices of Section meetings, to send to Section members notices of all Boston Society of Civil Engineer meetings, and to publish in its JOURNAL all suitable technical papers which may be presented by Section members to the Section or the Boston Society of Civil Engineers. In other words, by the proposed plan, existing machinery not now used to its full capacity would be at once made available to the Section, which, thus housed and equipped, would be in a much stronger position than if simply framed as a skeleton organization for discussions of national society policies. And the Boston Society of Civil Engineers at the same time would be strengthened by increased income and the greater activity centering about its headquarters.

We are strongly of the opinion that the formation of another independent local engineering organization would be a mistake and a step in the wrong direction at a time when there is a marked tendency toward coöperation and federation of engineering activities, and we believe that in recommending affiliation of the proposed Section with the Boston Society of Civil Engineers we are but following the precepts of the American Society as set forth in the rules governing the policy of local Sections adopted by the Board of Direction in 1917, which read as follows:

"Local Sections should recognize the advantage and necessity of cooperation with other engineering organizations in all ways that may strengthen the position of engineers, develop social relations among them, or tend to establish correct principles and practice.

"Local Sections should affiliate with existing engineering societies, and where none exists and conditions are favorable they should encourage their formation."

We further recommend that at the meeting to which this report is submitted, a committee be elected and empowered to effect the affiliation herein recommended, and to draft a constitution which shall embody the principles as outlined in this report.

F. A. BARBOUR, *Chairman.*
F. O. DUFOUR.
P. D. G. HAMILTON.
W. C. VOSS.
R. W. HORNE.
F. M. GUNBY.

The meeting to which this Report was made approved the recommendations and empowered the same Committee to proceed to carry out the recommendations contained in the Report.

That Committee has now drafted a Constitution and By-Laws for such a Section, and are proceeding with the necessary steps to consummate the formation of the Section, including the approval of the Constitution and By-Laws by the Board of Direction of the American Society of Civil Engineers. Copies of the proposed Constitution and By-Laws are attached. Without reading the whole of these, the following quotation from the proposed By-Laws provides for the affiliation with the Boston Society of Civil Engineers.

ARTICLE 1.

Section 1. For the better fulfilment of the "Objects" of its formation, as set forth in Article 2 of the Constitution, this Section shall be an "Affiliate Section" of the Boston Society of Civil Engineers; and, in its relation to that Society, it shall be known as the "American Society of Civil Engineers Section of the Boston Society of Civil Engineers."

Section 2. Affiliation with the Boston Society of Civil Engineers hall become effective upon the adoption of these by-laws by this Section, and acceptance of such affiliation on the part of the Boston Society of Civil Engineers.

As there are several interdependent steps in organizing this new Section, and effecting an affiliation, the committee has asked the Board of Government to present the matter to the Boston Society at this time. It will be noted that the difference between our dues for full membership and those proposed for this Section is just about equal to the cost of our JOURNAL. The Section members not members of the Boston Society of Civil Engineers would have no rights in the permanent funds.

The following are some of the advantages that would accrue to the Boston Society of Civil Engineers through the proposed affiliation:

1. It would be taking a definite step in the unification of engineering activities and sentiment in Boston and vicinity;

2. It would have centered within its headquarters the activities of another strong group in the engineering field, and should, thereby, gain additional support in the community;

3. Its professional activities should be greater because of the larger membership with a common interest;

4. Its financial position should be benefited by having some one else share in the expense and use of its quarters and secretarial staff;

5. This affiliation, if carried through, would be the first definite step in that "getting-together" of all engineering activities in this community which is so much to be desired.

In order to accomplish this affiliation, some changes will be necessary in the by-laws of the Boston Society of Civil Engineers, which were designed to provide for Sections entirely within the Society itself. The affiliation of the American Society of Civil Engineers Section could be made by making minor changes in the wording of the present by-laws of the Boston Society, as the Constitution and By-Laws of the new Section have been drafted with this affiliation in mind.

As there will doubtless be details in connection with the affiliation to be worked out as time goes on, it seems best to ask the Society to amend its by-laws, so that the Board of Government may be in a position to meet the situation as it develops, by adding the following:

"*Affiliate Sections:* The Board of Government may, from time to time, at its discretion, establish Affiliate Sections which shall be duly organized sections of kindred societies whose objects are in harmony with those of this Society. The requirements governing such Affiliate Sections shall be those governing Sections, as provided for under these by-laws, so far as applicable, with such modification as may be approved by the Board of Government as necessary to effect suitable working arrangements, having due regard to the interest of this Society."

The suggested change in the by-laws as outlined above will provide not only for the type of Section now under discussion, but, in addition, will cover possible applications for Sections of other societies that might desire to affiliate on some different basis, and we should be prepared to meet such contingency. For instance, in Greater Boston there are about 267 members of the American Society of Civil Engineers, approximately half of whom are also members of the Boston Society of Civil Engineers. There are 411 members of the American Society of Mechanical Engineers, of whom only 33 are members of the Boston Society of Civil Engineers; and there are 209 members of the American

Institute of Electrical Engineers, of whom only 14 are members of the Boston Society of Civil Engineers. The officers of both of the latter Sections have expressed some interest in a possible scheme of affiliation. In all probability, such an affiliation would be on a somewhat different basis from that herein proposed for the Civils, whose membership is much more duplicated, and whose technical work is more closely in line with that usually followed by this Society. It is, therefore, thought best to provide for Affiliate Sections by the addition of a broad clause in the by-laws.

It is therefore recommended:

(1) That this Society approve the affiliation of the "NORTHEASTERN SECTION" of the American Society of Civil Engineers with the Boston Society of Civil Engineers along the lines laid down in this Report.

(2) That the by-laws of this Society be changed by the addition of the above c ause providing for "Affiliate Sections."

For the Board of Government,
ROBERT SPURR WESTON,
President.

REPORT OF THE JOINT COMMITTEE ON THE LICENSING OF ENGINEERS.

APRIL 21, 1921.

TO THE MEMBERS OF THE
Boston Society of Civil Engineers, Board of Government,
Boston Section, American Institute of Electrical Engineers,
Boston Section, American Society of Mechanical Engineers,
Boston Society of Architects,
Boston Section, American Society of Heating and Ventilating Engineers,
Boston Section, American Institute of Mining and Metallurgical Engineers,
Boston Society of Landscape Architects,

Gentlemen,— The Joint Committee on Licensing of Engineers, which included a committee of the Boston Society of Civil Engineers and representatives of seven other societies, submitted to the members of their respective societies, on January

8, 1921, a report in which it was stated that on January 4, 1921, a petition was filed in the legislature of Massachusetts by the Boston Chapter of the American Association of Engineers, accompanied by a bill to provide for the registration of professional engineers and land surveyors. This report also stated that at a meeting of this committee, held on January 7, 1921, it was voted:

First. That legislation relative to the registration of architects and engineers by this year's session of legislature should not be recommended.

Second. That the Boston Chapter, American Association of Engineers, be requested to withdraw, for this year, its bill filed with the legislature to regulate the practice of the profession of engineering and land surveying.

This report was signed by all the thirteen members of the committee with the exception of the representative of the American Association of Engineers.

We now desire to state that the American Association of Engineers did not withdraw its petition to the legislature with its accompanying bill for the licensing or the registration of professional engineers and land surveyors, as recommended and requested in the aforesaid votes.

The character of the above bill was such that, failing its withdrawal, the committee felt strongly that the welfare of the profession demanded that it be vigorously opposed and that every effort be made to make it perfectly plain to the Committee on Mercantile Affairs of the legislature, to which the bill was referred, that it was not representative of the desires of more than a minority of the engineering profession in this Commonwealth.

As a committee whose members officially represented our various societies, we were instructed to study these matters and were free to form our own judgments in regard to them and to decide what the welfare of our respective professions demanded; but constitutional limitations made it impossible for us, as a committee, to go farther than this and oppose legislation in the names of the societies.

As individual members of our several professions, however, we were free to act according to our conscience, and as individuals we unanimously agreed to oppose the bill as actively as possible

ourselves, to urge our friends in the profession to do the same, and in order that our opposition might be as effective as possible, we agreed to be collectively represented by counsel.

A hearing on the bill was held by the Committee on Mercantile Affairs of the Massachusetts legislature on February 18, 1921. The bill in question was actively favored by counsel for the American Association of Engineers. The speakers in favor of the bill, however, were only persons introduced by their counsel, all of whom were understood to be members of the association.

Both the form of the bill, which contained many glaring defects and inequalities which were contrary to the spirit of appropriate legislation, and the principle of registration were vigorously opposed in person, by counsel, or by letter, by members of the seven other societies represented on our committee, as well as by members of the American Chemical Society, the Engineering Society of Western Massachusetts, and by other individual engineers. A count of those present before the legislative committee showed nineteen persons voting in favor of the bill against eighty-nine persons opposed to it.

The legislative committee recommended the bill be referred to the next annual session of the legislature, and this recommendation was adopted in the senate on February 24, 1921, and by the house on March 3, 1921.

In opposition to the bill it was made perfectly plain at the hearing that the general public in this Commonwealth appears to make absolutely no request for the licensing of engineers, or take any interest whatever in the measure.

The demand for licensing or registering engineers in this locality, so far as we have been able to observe, appears to come entirely from the American Association of Engineers. This evidence is further confirmed by the introduction of bills for licensing or registering engineers in practically all the states of the Union and by the active campaign in support of these measures during the present year, in all states in which such laws had not already been passed, by the American Association of Engineers.

It appears to be the fact that these petitions for registration in all the different states contain the proviso that membership in

the American Association of Engineers and in certain other professional societies shall be a sufficient requirement for registration as an engineer.

The reasons stated in the bills favored by this association and advanced at the committee hearing for the passage of such a bill in this Commonwealth were for the purpose of safeguarding life, health and property. The life, the health and the property of the public, it was claimed, were in the hands of the engineers who were responsible for the structures and public works that the people use or enjoy, and it was stated that existing laws did not sufficiently protect the public in these directions. It was claimed by the advocates of the bill that a licensing law such as this bill provided would furnish the necessary protection. One of the proponents at the hearing, however, was frank enough to admit that young engineers without reputation would welcome an opportunity to obtain a license which would appear to put them on a par with the better known and more experienced men in the profession.

Prof. George F. Swain pointed out at the hearing, in the clearest way possible, the character and the extent of the safeguards to the public that exist at the present time relating to the construction of buildings, public and private utilities, etc., through supervision by competent commissions and engineers, through building laws and other special laws requiring official supervision and approval of plans, inspection of work in process and of finished work, and expressed the opinion that if such measures were not sufficient that the wise policy would be to add to them and to amend them in such a way as to cure their defects, but that no possible method of registering engineers could take their place or could provide a system of safeguards to society that was comparable with them in effectiveness.

An engineer is not usually chosen in a hurry or for work of an emergency nature, and in engaging an engineer to design engineering work of greater or lesser importance, a client now considers the professional reputation and work accomplished by the engineer whom he is to employ. Public or private interests are better safeguarded by such practice than by selecting an engineer by virtue of his holding a license.

It was demonstrated at the hearing under the proposed bill, that a person who became registered, through society membership or otherwise, would be, in the eyes of the law, fully competent to practice every branch of engineering, regardless of the field in which his training or experience had been. A system of licensing which provides for competency in one field may open up an opportunity for incompetence in others.

It is an open question as to what extent licensing laws should go in the registration of applicants; if the requirements of the examining board call for professional attainments of the highest order, the result would be public confidence in a registered engineer. If licenses are issued to men of mediocre or inferior ability, many would obtain licenses and have the same standing before the public as those of much greater professional attainments and reputation, with the result that public and private interests would suffer from work of inferior character.

A favorite reason advanced for licensing laws is that they are being passed in other states, and we shall be forced to it here. This argument is obviously of the weakest character and sustains a policy of blindly following the lead of others without individual thought as to resulting benefits or disadvantages of a proposition. Many states have statutes which in others are considered inadvisable and inexpedient to copy.

One of the principal arguments that was used in favor of registration is the necessity for reciprocity with other states. The provisions of the different laws now in effect are considerably at variance in this respect. A law passed in any one state cannot compel other states to recognize their registration, and in some states requirements for registration are likely to be of a higher standard than in others, thus defeating mutual reciprocity.

Individual engineers and engineering firms and corporations which do business in several states are comparatively few in number as compared with the total number of men in the various branches of the profession. The obtaining of licenses in any one state is not a great hardship for any such, but to obtain separate licenses in a number of states is an inconvenience and source of expense.

What is an engineer? One of the greatest difficulties in licensing engineers is deciding this question. Some laws define an engineer or engineering; others avoid it entirely, leaving it in case of litigation or similar difficulty for the courts to decide. If engineers themselves, in framing laws for registration, cannot define what an engineer is, it can hardly be expected that the courts, which are dependent in technical questions upon expert testimony, can prepare a suitable definition of engineering. There have been many attempts to so define the profession, and with indifferent success. Many such definitions specify special branches and wind up with a blanket clause at the end to cover all other branches of engineering, with the result that the branches of the profession previously designated might as well be omitted. It is a question how laws can be framed to effectively and properly regulate anything that cannot be definitely and comprehensively defined.

The divisions of engineering cover work of many varieties, many of which have absolutely no relation to each other, and nearly sixty different branches of engineering may be quoted by title. Most of the laws appear to make no distinction between the different fields of engineering activity, and the registered engineer in the eyes of the law may be equally competent to act as a chemical engineer, an electrical engineer, an efficiency engineer, a mechanical engineer, or a municipal engineer, all typical of most widely diversified branches of the profession.

In this connection, it is difficult to comprehend how a man registered as an engineer and whose principal knowledge is confined to, say, mechanical engineering, is any more qualified to pose as a chemical engineering expert than would be a lawyer, a physician or a plumber, for instance, or a person skilled in many other professions or trades, provided their general educational qualifications correspond.

A small percentage of the laws in effect require that applicants for registration shall be citizens of the United States, but the Engineering Council model law and the American Association of Engineers proposed laws contain requirements that such applicants shall be citizens of the United States or of Canada. Such a requirement is most provincial, and is distinctly opposed

to Massachusetts law and precedent in particular, which requires applicants for registration in other professions to be only of good moral character, in addition to educational or professional qualifications. Such requirement savors strongly of the "closed shop" of the labor unions, is most unfair discrimination in favor of Canadians as against other British subjects, and furthermore is extremely un-American. American engineers should certainly not be so narrow-minded as to fear foreign competitors or oppose their registration, and may learn much by association with men conversant with foreign technical practice.

Some of the proposed laws provide that structures or work costing less than a certain sum need not be designed by a registered engineer. The safety of the public may be vitally endangered in many instances by an inexpensive structure. Some of the laws also provide that structures may be built by owners, whether persons or corporations, on their own property, which are not designed by registered engineers. It may be noted that in all localities where building laws are deemed necessary, it is doubtful that a building law can be found that will allow a man to build for his own use or occupancy a house that is not constructed in conformity with the building code of such city.

Laws for the licensing of engineers should also include the licensing of architects and affiliated professions, for the reason of the two professions being so closely interwoven that they are mutually interdependent in many ways. An architect must be more or less familiar with many branches of engineering, and an engineer is frequently obliged to consider the architectural appearance of his structures.

Fees for registration and annual renewal of licenses, where the latter are required, is a not unimportant item of expense to many.

Believing that legislation will again be requested, the undersigned committee recommends that it or a similar one be continued during the coming year, to further study the matter of licensing or registration of architects, engineers and land surveyors, and that other engineering or architectural societies be invited to add their representatives to its membership and so continue a joint committee on the licensing of the members of such professions.

In conclusion we desire to state that in presenting this report we have endeavored to take no partisan view, but merely to give to the members of our respective societies an accurate perspective of the history of this case and a description of the things that took place at the hearing referred to, together with a few thoughts on the principle of licensing.

Respectfully submitted,

JOINT COMMITTEE ON LICENSING ENGINEERS.
(Majority of 12 of the 13 members.)

CHARLES T. MAIN,
CHARLES M. SPOFFORD,
CHAS. R. GOW,
CHARLES W. SHERMAN,
I. E. MOULTROP,
EDWIN H. ROGERS, *Chairman*,
Representing Boston Society of Civil Engineers.

L. W. ABBOTT,
Representing Boston Section, American Institute of Electrical Engineers.

ARTHUR L. WILLISTON,
Representing Boston Section, American Society of Mechanical Engineers.

C. H. BLACKALL,
Representing Boston Society of Architects.

ALLEN HUBBARD,
Representing Boston Section, American Society Heating and Ventilating Engineers.

EDWARD E. BUGBEE,
Representing Boston Section, American Institute Mining and Metallurgical Engineers.

BREMER W. POND,
Representing Boston Society of Landscape Architects.

APPLICATIONS FOR MEMBERSHIP.

[June 15, 1921.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Maxwell, Harold Frederick, Dorchester, Mass. (Age 26, b. Malden, Mass.) Had a three years' course in civil engineering at Northeastern College, 1913–1916. Since that time he has been in the employ of the State, in the Department of Public Works, Division of Highways, as rodman, transitman, and later as assistant resident engineer. From the latter part of 1917 to January, 1919, he was with the 101st U. S. Engineers, A. E. F., and after his discharge he returned to the Public Works Dept., and is at present assistant to the construction engineer, District No. 4. Refers to A. B. Appleton, R. W. Coburn, L. B. Hoyt, and A. P. Rice.

LIST OF MEMBERS.

ADDITIONS.

Allen, John S.	Walpole, Mass.
Dufour, Frank O.	147 Milk St., Boston 9, Mass.
Flynn, Francis T.	141 Millet St., Dorchester, Mass.
Macaulay, Ralph F.	1996 Mass. Ave., Cambridge 40, Mass.
MacWilliams, Harold F.	360 High St., Newburyport, Mass.
Ryan, Edward J.	703 City Hall Annex, Boston 9, Mass.
Steward, Douglas P.	90 Forest St., Medford, Mass.
Vaughan, John F.	185 Devonshire St., Boston, Mass.

CHANGES OF ADDRESS.

FORD, ARTHUR L. ..... 9 Sutton Ave., Juniper Pt., Salem, Mass.
JONES, FREDERICK E. ..... 80 Elm St., W. Somerville, Mass.
KIMBALL, HERBERT S. ..... 79 Milk St., Room 1111, Boston 9, Mass.
LELAND, FRANKLIN E. ..... 155 Newbury St., Roslindale, Mass.
RHODES, RALPH F. ..... U. S. Engineers' Office, Savannah, Ga.
TOSI, JOSEPH A. ..... 84 Bay State Road, Worcester, Mass.
VAN DER PYL, EDWARD ..... 63 Barber Ave., Worcester, Mass.
WILBER, JOSEPH F. ..... 210 South St., Boston, Mass.

DEATHS.

NOWELL, FRANK J. ..... May 25, 1921

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

International Congresses: Civil Engineering at Exposition, Brussels. 1910.

International Congresses: Ocean and Inland Navigation. 1913.

International Congresses: Rivers, Canals and Ports. 1912.

International Congresses: Shipbuilding from its beginning. (3 vols.) 1895-1905.

International Congresses: 12th Congress: 1st Sec. Questions.

International Congresses: 12th Congress: 1st Sec. Communications.

International Congresses: 12th Congress: 2d Sec. Questions. 1912.

International Congresses: 12th Congress: 2d Sec. Communications.

Triangulation in Rhode Island. Serial No. 121. By Earl Church.

Water Supply Papers Nos. 466, 481, 500-A.

State Reports.

Vermont. Special Report Water Resource Commission. 1921. By State Engineer in coöperation with C. H. Pierce, Dist. Engr. U. S. Geol. Survey.

Municipal Reports.

Chicago, Ill. Report on Industrial Wastes. Vol. 2. 1921.

Haverhill, Mass. Annual Report Board of Water Commissioners. 1920.

North Adams, Mass. Annual Report City Officers. 1920.

Northampton, Mass. Annual Report Water Commissioners. 1920.

St. Paul, Minn. Annual Report Board of Water Commissioners. 1920.

Springfield, Mass. Annual Report Water Commissioners. 1920.

Springfield, Mass. Report Municipal Water Works. 1920.

Wellesley, Mass. Annual Report Water and Municipal Light Commissioners. 1920.

Miscellaneous.

American Engineers in France. William B. Parsons. (Gift of Clemens Herschel.)

Further Incidents in the Life of a Mining Engineer. E. T. McCarthy. (Gift of Clemens Herschel.)

Finding and Stopping Waste in Modern Boiler Rooms. Cochrane Corp.

Forests of British Columbia. Commission of Conservation. Canada.

The Canadian Oyster. Commission of Conservation. Canada.

LIBRARY COMMITTEE.

Vol. VIII SEPTEMBER, 1921 No. 7.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Inverted Siphons for Sewers" — Final Report of Committee.

Memoir of Deceased Member.

MINUTES OF MEETING.

NORUMBEGA PARK, June 15, 1921. — The regular meeting of the Society was held at Norumbega Park, Auburndale, Mass., and was called to order at 6.10 P.M. by the President, Robert Spurr Weston.

There were 33 members and visitors present.

It was voted to dispense with the reading of the minutes of the last meeting.

The President announced that the Board of Government had reinstated Mr. Henry B. Alvord.

The President also announced the death of Mr. Frank J. Nowell on May 25, 1921. Mr. Nowell became a member last February.

It was voted that the President be authorized to appoint a committee to prepare a memoir of John F. Monaghan and one of Frank J. Nowell.

On motion of Col. Gunby, it was unanimously voted that the By-Laws of the Society be changed by inserting the following paragraph:

"*Affiliate Sections:* The Board of Government may, from time to time, at its discretion, establish Affiliate Sections, which shall be duly organized sections of kindred societies, whose objects are in harmony with those of this Society. The requirements governing such Affiliate Sections shall be those gov-

erning Sections as provided for under these by-laws, so far as applicable, with such modification as may be approved by the Board of Government as necessary to effect suitable working arrangements, having due regard to the interests of this Society."

This vote having been unanimously passed at two successive meetings of the Society, the By-Laws are therefore amended in accordance therewith.

Adjourned at 6.20 P.M.

RICHARD K. HALE, *Acting Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[September 15, 1921.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BRENNAN, FRED S., Somerville, Mass. (Age 38, b. Boston, Mass.) Educated in Somerville public schools, Boston College High and Y. M. C. A. evening school. Has had experience on building as clerk, assistant superintendent and superintendent, supervising, estimating, designing, etc., for twenty-one years. Refers to J. E. Hanlon, E. S. Parker, G. F. Temple and J. F. Travers, Jr.

MANNING, JAMES HENRY, Brookline, Mass. (Age 38, b. Fall River, Mass.) Graduated from Worcester Polytechnic Institute, 1906. He has had four years experience in field and office on concrete construction, three years

with Stone & Webster Co., Inc., as superintendent of construction on three hydroelectric plants, as consultant, and finally as head of the hydraulic division; three years as chief engineer American International Shipbuilding Corporation, in charge of the planning and designing of Hog Island shipyards; and from August, 1919, to date as assistant engineering manager in administrative charge of the engineering department. Refers to C. M. Allen, F. O. Dufour, C. T. Main, W. N. Patten, A. T. Safford, and D. M. Wood.

LIST OF MEMBERS.

ADDITIONS.

ABBOTT, H. KINGMAN.....20 Pleasant St., Reading, Mass.
ALVORD, HENRY B.,
Professor at Northeastern College, 316 Huntington Ave., Boston, Mass.
BROSNAHAN, JOHN E.....Asst. Engr., 709 City Hall Annex, Boston 9, Mass.
DEMERRITT, ROBERT E.....Officer U. S. Army, Fort Sherman, C. Z.
GIANNI, PLACIDO.....Draftsman, 119 Harrison Ave., Roxbury, Mass.
SULLIVAN, DANIEL M.,
C. E. Public Works Dept., Boston, 59 St. Andrew St., East Boston, Mass.

CHANGES OF ADDRESS.

BIGELOW, WILLIAM W.....Technology Chambers, Boston, Mass.
BROOKS, CLARENCE M.....Highway Dept., Montpelier, Vt.
BROWN, WILLIAM A.....9 Loring St., Waverley, Mass.
BURLEY, HARRY B.....65 Bay St., Dorchester, Mass.
BURPEE, GEORGE W., Care Coverdale & Colpitts, 66 Broadway, New York, N.Y.
CARSON, HOWARD A.....79 Glenwood St., Malden, Mass.
CLAPP, FREDERICK O.....10 Barnes St., Providence, R. I.
COREY, KENNETH T.....106 Oakland St., Springfield, Mass.
EMERSON, GEORGE D.....Cocoanut Grove, Fla.
GROVER, NATHAN C.....1442 Belmont St., Washington, D. C.
HART, FRANK S.....12 Warren Road, Framingham, Mass.
LEARNED, WILBER F.....Cons. Engr., Town Hall Bldg., Watertown, Mass.
MIRICK, GEORGE L.....8 Avon St., Suite 6, Cambridge, Mass.
MOORE, RUFUS R.....93 Binney St., Boston, Mass.
MORTENSON, ERNEST D.....8 Akron St., Roxbury 19, Mass.
MOULTON, J. WENDELL.....800 Washington St., Dorchester, Mass.
SHAW, EDWARD W.....154 Austin St., Worcester, Mass.
SMITH, MERRITT P.....Decatur, Mich.
STEARNS, GEORGE H.....R. F. D. No. 1, Medway, Mass.
STEARNS, RALPH H.....101 Nehoiden Road, Waban, Mass.

DEATHS.

AIKEN, ROY C.....June 24, 1921.
BACON, W. HERBERT.....August 27, 1921.
HUTCHINSON, RICHARD.....June 15, 1921.

LIBRARY NOTES.

Book Reviews.

CONCRETE DESIGNER'S MANUAL.

Tables and Diagrams for the Design of Reinforced Concrete Structures. By George A. Hool, S. B., Consulting Engineer, Professor of Structural Engineering, The University of Wisconsin, and Charles S. Whitney, M. C. E., Structural Engineer, Milwaukee, Wisconsin. First Edition. McGraw-Hill Book Company, Inc., New York, London. Flexible binding; 6 x 9 in.; pp. 276; diagrams 66; tables 54*. Price $4.00.

Reviewed by Frank A. Marston.*

The use of diagrams and tables greatly facilitates the design of reinforced concrete structures. Therefore, a book which contains well prepared information of this sort is sure to be favorably received by those who understand the principles of reinforced concrete design and who are actively engaged in such work. Like any handbook, the Concrete Designer's Manual will prove more valuable according to the designer's familiarity with its pages.

The diagrams and tables have sufficient range to be of use in the problems generally encountered in the design of buildings, walls, arches, and other engineering structures.

The arrangement of the diagrams is good, they are easy to read, and require only a moderate amount of use to make them as valuable to the designer as his own pet diagram for the design of beams and slabs.

The authors have offered this collection of diagrams and tables to the profession with the belief that they are in convenient form and have been thoroughly tried out in practice. Some of the diagrams are in familiar form, as, for example, the diagram for rectangular beams for values of $\frac{M}{bd^2}$, k, j, and p, which form was originally published by Prof. Arthur W. French in Trans. Am. Soc. C. E., Vol. LVI, p. 362, June, 1906, and since then by many others.

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

The Manual is designed to facilitate the design of reinforced concrete structures in accordance with the Joint Committee Recommendations of 1917, the American Concrete Institute Recommendations, the New York Building Code or the Chicago Building Code. A material change in any of these standards will of course affect to some extent the value of the corresponding tables and diagrams. Part of the material in the Manual, however, is of a sufficiently general nature as to be unaffected by the changes above mentioned.

Diagrams are given for values of the allowable stress in concrete of 650, 700 and 750 lbs. per sq. in. respectively; for values of the allowable stress in steel reinforcing bars of 16,000 and 18,000 lbs. per sq. in.; and for values of $n = 15$. For some classes of structures somewhat lower stresses, particularly for concrete, have been deemed advisable by some designers.

The tables covering the design of flat slab floors according to three standards for various loadings, both with drop panels and cap construction, will be found particularly suggestive in the preliminary design of floors and roofs.

Considerable space has been allotted to tables covering the design of square and round columns.

The section on "Bending and Direct Stress" contains tables and diagrams that will shorten considerably the work of design in such problems.

The section on "Footings" contains data that will be welcomed by many designers.

No attempt has been made in this review to cover all of the excellent features of the Manual. Its value to the designer will grow with use; and, in addition, many of the miscellaneous diagrams and tables not commonly given in books on concrete design will be found of sufficient worth in themselves to justify the placing of this book in the concrete designers' working library.

COLLECTION AND DISPOSAL OF MUNICIPAL REFUSE.

REVIEWED BY DWIGHT PORTER.*

By Rudolph Hering, D. Sc., New York City, Past President of American Public Health Association and of Engineers Club of Philadelphia, Past Vice-President of American Society of Civil Engineers, member of American Institute of Consulting Engineers, American Society of Mechanical Engineers, Institution of Civil Engineers, London Engineering Institute of Canada, Western Society of Engineers, etc., and Samuel A. Greeley, Chicago, Ill., member of American Public Health Association, American Society of Civil Engineers, Western Society of Engineers, American Association of Engineers, American Water Works Association, Illinois Society of Engineers, etc. New York and London: McGraw-Hill Book Co., Inc. Paper, 6 x 9 in.; pp. 653; illustrated. $7.00.

The engineering profession will welcome to its literature this treatise on a highly important branch of municipal work. Clear, comprehensive, and admirably presented, it is bound to rank as an accepted standard for many years. Mr. Hering's experience as an engineer, his long and wide professional acquaintance with general sanitary practice on both sides of the Atlantic, and in particular his leadership in movements to develop the art of refuse disposal, and his special investigations of the problem for various cities, have fitted him preëminently to deal with the subject. His younger associate, Mr. Greeley, has been excellently prepared by education, by investigations abroad as well as in this country, by responsible charge of various features of refuse disposal in Milwaukee, and by his specialized practice as a consulting engineer, to collaborate with the senior author.

Preparation of this book was begun some ten years ago. Only about twenty-five years earlier the first organized effort in this country was made, through a committee of the American Public Health Association, to investigate as to the best methods of garbage disposal, and in 1894 Mr. Hering was made chairman of the committee. Present modes of refuse disposal are not in general character different from those approved by that committee. Experience in the intervening years, however, has

* Professor of Hydraulic Engineering, Mass. Institute of Technology.

furnished extensive data, through municipal records, technical analyses and tests, as to quantity and quality of refuse, cost of collecting and of disposing, and has thus made more practicable a logical choice of method for a given community. While further advance may yet be made, through standardized statistics, better organization, and guidance from engineers and sanitarians, the authors believe that the period of conjecture and experiment is nearly past.

As a rule, each chapter opens with a brief introductory outline of the topic to be taken up, and at the close of the chapter there is a concise summary and statement of conclusions. The outstanding features are thus brought into prominence, while details may be found in the intervening pages. The literary style is most attractive, and is worthily supported by judicious subdivision into sections, and excellent typography. Interspersed in the text are some seventy photographic reproductions, and nearly an equal number of drawings and diagrams. In addition, there are not less than one hundred and eighty numbered tables,— possibly a superabundance, but furnishing a large fund of carefully selected data for reference. The value for this purpose, both of tables, and of illustrations, would have been increased by lists accompanying the table of contents.

The general treatment may be outlined as follows: An opening chapter gives definition of terms as used for the different kinds of municipal refuse, a detailed classification of its more common constituents, references to important sources of information, and fundamental data as to quantities of refuse, physical and chemical composition, and the causes and extent of their variations.

Then comes the handling of refuse at its point of origin, prior to collection, here spoken of as "house treatment," which has an important bearing on the appearance of the yards and alleys of a town, and which must be consistent with the method adopted for public collection and disposal. Allusion is made to the exceptional practice of draining house garbage and wrapping it in paper, as required of householders in Minneapolis and Trenton, N. J.; to the temporary cold storage of restaurant garbage in the Pennsylvania Railroad Stations in New York and

Washington; and to the marked effect of the recent war on the amount and composition of city garbage.

Logically, the collection of refuse is next considered, a service which is stated to be normally more expensive than the final disposal. Collection is therefore treated in much detail as to types of equipment, capacity per wagon, frequency of collection, horse-drawn *vs.* motor vehicles, municipal operation *vs.* that by contract, supplemental transportation from relay stations, and so on.

The main problem is that of final disposal. Methods variously open for this are presented in chapters on deposition in water and on land, feeding garbage to hogs, refuse incineration, and garbage reduction. The last mentioned, and distinctly American, practice of treating garbage to secure grease and "tankage" has been favored by the relatively high percentage of grease found in the garbage of our cities, but the authors suggest that in due time this advantage may be lessened by closer approach to the more economical standards of Europe. In spite of the fact that about half of the reduction plants built in this country have been abandoned because of nuisance, fire, or explosion, numerous installations are still in operation in the large cities, in which alone they are profitable.

Disposal of stable refuse, street refuse, night-soil, and dead animals is discussed in final chapters, and, lastly, the important topic of procedure for small towns and villages. Street cleaning is considered too large a subject, however, to be handled with thoroughness in this volume.

Much attention is given throughout to the economics of refuse collection and disposal, as is shown by chapters devoted, respectively, to estimating the cost of collection and transportation, and to estimating costs of final disposal, an article on computations for collection service, diagrams of haulage costs, and a wealth of actual cost data in various tables.

Commendable fairness is shown by the authors in presenting both the advantages and the disadvantages of alternative methods, such, for example, as incineration and reduction. Their purpose plainly is to set forth the principles, and state the facts, upon which may be based a wise choice of method for each particular problem.

Recent Additions to the Library.

U. S. Government Reports.

Annual Reports of Library of Congress, 1915, 1916, 1917 and 1918.

Cotton Production in the United States. 1920.

Financial Statement of Cities. 1909, 1910, 1911, 1912. Department of Commerce.

General Statistics of Cities. 1909. Department of Commerce.

Mortality Statistics, 1917. Department of Commerce.

Regional Development of Pulpwood Resources, Alaska. C. G. Smith.

Relation Between Plane Rectangular Coördinates and Geographic Positions. W. F. Reynolds. U. S. Coast and Geodetic Survey.

Statistics of Cities. 1908. Department of Commerce.

Statistics of Railways of United States. 1918. Interstate Commerce Commission.

Special Reports Street and Electric Railways. 1902. Department of Commerce.

Water Supply Papers, 468, 490-B, 471, 500-B.

State Reports.

New York. New York, New Jersey Port and Harbor Development Commission, Joint Report. 1920.

New Jersey. Annual Report of Department of Health. 1920.

Maine. Annual Report of Water Power Commission. 1920.

Maine. Annual Report of Public Utilities Commission. 1920.

Pennsylvania and New Jersey. Report of Board of Engineers to Delaware River Bridge Joint Commission. 1921.

Municipal Reports.

Bangor, Me. Annual Report of Water Board. 1920.

Brockton, Mass. Annual Report of City Engineer. 1920.

Brockton, Mass. Annual Report of Sewerage Commissioners. 1920.

Chelsea, Mass. Annual Report of Water Commissioner. 1920.

Concord, N. H. Annual Report of Board of Water Commissioners. 1920.

Detroit, Mich. Annual Report of Board of Water Commissioners. 1920.

Fall River, Mass. Annual Report of Watuppa Water Board. 1920.

Fall River, Mass. Annual Report of City Engineer. 1920.

Leominster, Mass. Annual Report of City Government. 1920.

Melrose, Mass. Annual Report of Board of Park Commissioners. 1920.

New Bedford, Mass. Annual Report of Engineering Department. 1920.

New York, N. Y. Annual Report of Board of Water Supply. 1920.

Northampton, Mass. Annual Report of City Officers. 1920.

Providence, R. I. Annual Report of City Officers. 1920.

Taunton, Mass. Annual Report of Water Commissioners. 1920.

Waltham, Mass. Annual Report of Department of Public Works. 1920.

Woonsocket, R. I. Annual Report of Board of Water Commissioners. 1920.

Worcester, Mass. Annual Report of Superintendent of Sewers. 1920.

Miscellaneous.

Collection and Disposal of Municipal Waste. Hering and Greeley.

Concrete Designers' Manual. Hool and Whitney.

Engineering Index. 1920.

Handbook of Construction Equipment. Richard T. Dane.

Proceedings of National Association of Cement Users, Vol. 8, 1912.

Rainfall and Run-off in the Miami Valley. Ivan E. Houk. Part 8.

Water Powers of British Columbia. Arthur V. White.

LIBRARY COMMITTEE.

PROPERTY OF THE NORTHEASTERN COLLEGE ENGINEERING SCHOOL

Vol. VIII OCTOBER, 1921 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"In Memory of Samuel Everett Tinkham."
His life as a young man. E. W. Howe.
His connection with the Boston Society of Civil Engineers. Desmond FitzGerald.
His services as an engineer. F. H. Fay.
A brother Mason's tribute. J. K. Berry.

MINUTES OF MEETING.

BOSTON, September 21, 1921. — The regular meeting of the Society was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.00 o'clock P.M. by the President, Robert Spurr Weston.

There were 33 members and guests present.

The minutes of the meeting of June 15 were read and approved.

The President announced that the Board of Government had elected the following to membership in the grades named:

Members — Messrs. Robert W. Kent, Harold F. Marnell, Thomas Mulcare and Reeves J. Newsom.

Junior — Mr. Vivanio L. Valdes.

The President announced the deaths of the following: Richard Hutchison, who died June 15, 1921; Roy C. Aiken, who died June 24, 1921; W. Herbert Bacon, who died August 27, 1921; and it was voted that the President be authorized to appoint committees to prepare memoirs of the deceased members.

The President presented the report of the Tinkham Memorial Committee, and stated that it had been approved by the Board of Government and that he had been instructed to inform the Society that it was the opinion of the Board that the fund be increased to six thousand dollars, so that a full scholarship could be provided. It was voted to accept the report of the Tinkham Memorial Committee and to endorse the action of the Board of Government thereon.

The Committee on the Tinkham Memorial presented a photograph of the late Secretary, S. Everett Tinkham, which was accepted by the President.

The speakers of the evening were then introduced, the first speaker being Past President Edward W. Howe, who read a paper on Mr. Tinkham's personal life. J. K. Berry, Esq., was then called upon to speak on Mr. Tinkham's Masonic career. Past President Frederic H. Fay presented a paper on Mr. Tinkham's career as an engineer, and Past President Edward W. Howe read a paper prepared by Past President Desmond FitzGerald, on Mr. Tinkham's connection with the Boston Society of Civil Engineers.

After extending a vote of thanks to Mr. Berry, the meeting adjourned.

RICHARD K. HALE,
Acting Secretary.

REPORT OF THE COMMITTEE ON THE TINKHAM MEMORIAL.

AUGUST 23, 1921.

Mr. ROBERT SPURR WESTON,
Boston Society of Civil Engineers,
Tremont Temple, Boston, Mass.

Dear Sir, — The committee appointed to consider a memorial for Mr. S. E. Tinkham begs leave to report to the Board of Government, through the President, that it had considered various forms of memorial, and recommends to the Board, as the most suitable form, the creation of a fund for scholarship or fellowship in research work at the Massachusetts Institute of

Technology, to be known as the "S. E. Tinkham Memorial Fund."

The committee has also arranged for the unveiling of a suitable picture at the Memorial Meeting, to be held in September, at which various addresses are to be given regarding the various activities of his life.

Very truly yours,

(Signed) JOHN E. CARTY,
Secretary of the Committee.

APPLICATIONS FOR MEMBERSHIP.

[October 15, 1921.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

HOLMGREN, RICHARD SIGFRID, Lynn, Mass. (Age 26, b. Worcester, Mass.) Attended Lynn English High School, and worked afternoons as rodman and instrumentman with local surveyor. From Aug., 1914, to Aug., 1915, worked as chainman and computer on valuation of the Bay State Street Railway. Graduated from Mass. Institute of Technology in 1920. From June, 1920, to Nov., same year, worked as transitman for H. K. Barrows, in Salem, N. H.; from Nov., 1920, to June, 1921, was assistant engineer with L. H. Shattuck, Inc., on sewer survey and study of sewerage system of Manchester, N. H.; June to Sept. 1 was draftsman and designer with the Holyoke Water Power Co.; Sept. 1 to the present, assistant engineer on the construction of a dam at Salem, N. H., for H. K. Barrows. Refers to H. K. Barrows, C. A. Moore, P. A. Shaw and G. G. Shedd.

LIST OF MEMBERS.

ADDITIONS.

MARNELL, HAROLD F.....192 Quincy St., Dorchester 21, Mass.
NEWSOM, REEVES J.,
Commissioner Water Supply, Lynn, Mass., 11 Hovey Terrace, Lynn, Mass.
SHEA, JOSEPH T.....14 Haskell St., Cambridge, Mass.

CHANGES OF ADDRESS.

BARRY, C. GARDNER.....75 Gainsborough St., Suite 4, Boston
CHAPMAN, BENJAMIN R.....City Hall, Everett, Mass.
DASHPER, FRED C.....30 Leinster Sq., Bayswater, London, W. 2
FLETT, LOUIS E.....154 Youle St., Melrose, Mass.
HASTIE, FRANK B.....Camp A. A. Humphrey, Va.
HERING, RUDOLPH.....40 Lloyd Road, Montclair, N. J.

DEATHS.

HABERSTROH, CHARLES E.....September 25, 1921
MILLS, HIRAM FRANCIS.....October 4, 1921

LIBRARY NOTES.

BOOK REVIEWS.

"HANDBOOK OF CONSTRUCTION EQUIPMENT," by Richard T. Dana, consulting engineer. First edition. New York, McGraw-Hill Book Company. Leather, 4½ x 7 in.; 1 vol., pp. 849, figures and tables.

REVIEWED BY J. ARTHUR GARROD.*

The handbook compiled by Mr. Dana is in compact form and clearly printed. It describes nearly all types of equipment generally used, and some which are only occasionally employed in construction work.

It treats not only of the newer and more complicated pieces of machinery, but compares the relative efficiency of such simple and familiar pieces of equipment as scrapers, hand shovels and wheelbarrows, when used under given conditions. It enters into some detail of such large pieces of equipment as dipper and clam-shell dredges.

* Superintendent Aberthaw Construction Co., 27 School St., Boston, Mass.

The arrangement of the book gives:

First, a statement of general principles and an explanation of ways recommended of using the information which follows.

Second, an alphabetical description of the pieces of equipment.

This arrangement appears to be more suitable than any other which could have been adopted, although the work, like the dictionary, becomes thereby "interesting, but rather disconnected."

The handbook is complete with charts, tables of costs and other data, which should be of considerable value to the engineer who has to suggest or pass upon methods of work and the necessary equipment, as well as the engineering contractor whose success or failure depends so largely upon the equipment and methods he employs.

There are frequent references to the authority for most of the articles in this compilation which should give those who have to give these matters more exhaustive study, a right start in investigating the special problems in question.

The prices quoted throughout are stated to be those of 1920. The changes in prices that have taken place since this time are considerable and not always consistent; still, the figures given should afford some guide even to-day as to what price may be expected and calculated upon when preliminary estimates are being made.

The section dealing with rental charges contains some suggestive data and methods for comparing the first cost with the rentals. This section appears to be rather scanty when the importance of the subject to the contractor and engineer is considered.

An appendix gives classified names of dealers and manufacturers of contractor's plant throughout these United States. A casual examination will show this to be far from complete. Those from whom used plant can be rented or purchased are omitted altogether.

The perusal of this book has proven helpful to the reviewer who is daily engaged in actual construction work. It should prove valuable to all engaged in a like business.

"LOCATION, GRADING AND DRAINAGE OF HIGHWAYS," by Wilson G. Harger, C. E. First edition. New York, McGraw-Hill Book Company. Cloth, 6 x 9 in.; 1 vol., pp. 294, figures, maps and tables.

REVIEWED BY DAVID A. AMBROSE.*

The importance of studying the highway program for a general scheme to meet the requirements and of "starting right" are emphasized in this book.

Chapter I presents the general principles of economic design, with mileage as the most important factor of service. The summary on page 27, which invites attention to the eleven important principles discussed, is excellent.

Chapter II takes up the important features of design, including selection of the best general route, selection of the most natural engineering location following the desired general route, and improvements for the future.

The general survey of the road problem in Chapter III contains classification, route, and the problem of financing road construction. The reader will find the discussion of grades and alignment in Chapter IV of great interest, and it brings out clearly the fact that grades and alignment are fundamental, permanent features of highway improvement.

Chapter V takes up the cross-sections of rural roads, widths of pavements, right of way and clearing, with many figures showing typical sections of roads in many states and of types recommended.

In the last chapter the problem of drainage includes types of bridges and culverts, surface drainage and underdrainage.

There are six chapters, covering 278 pages, in this volume.

This book is the first of a series of four volumes, and, as the author states, is intended for the use of students and practicing engineers. It is of distinctive value in its discussion of the permanent features of highway construction.

* First Asst. Engineer, Mass. Metropolitan Park Commission, 18 Tremont St., Boston, Mass.

Recent Additions to the Library.

U. S. Government Reports.

Fourteenth Census of the United States. 1920.
Housing and Town Planning. Report. 1920.
Twenty-three Topographical Maps.
Water-Supply Papers, 459, 460, 475, 476.

State Reports.

Massachusetts. Annual report of Public Utilities. 1920.
New Jersey. Annual report, Department of Conservation and Development.

Municipal Reports.

Boston, Mass. Boston's Streets. 1919 and 1921.
New York, N. Y. Depreciation Charges of Railroads and Public Utilities. Carter and Ransom.

Miscellaneous.

A. M. S. T. Standards, 1921.

The following were contributed by Babcock & Wilcox Co.:

Boiler Code. Am. Soc. Mech. Engrs.
Heat Transfer.
Marine Steam.
Principles of Combustion.
Recent Developments in Oil Burning.
Steam, Its Generation and Use.
Unusual Efficiencies in an Oil Fuel Installation.

Library Committee.

Vol. VIII NOVEMBER, 1921 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Federal Water-Power Legislation." G. C. Danforth.

MINUTES OF MEETING.

BOSTON, October 19, 1921. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at eight o'clock by the President, Robert Spurr Weston.

There were 34 members and guests present.

The minutes of the meeting of September 21 were read and approved.

The President announced that the Board of Government had elected the following to membership in the grade named:

Members — Messrs. Fred S. Brennan and James Henry Manning.

The President announced the deaths of the following members: Mr. Charles E. Haberstroh, who died September 25, 1921, and Mr. Hiram Francis Mills, who died October 4, 1921; and it was voted that the President be authorized to appoint committees to prepare memoirs of the deceased members.

On motion of Past President Swain it was voted that the Board of Government be authorized to use the income from the Permanent Fund to meet current expenses to such an extent as they deemed necessary.

The President then introduced the speaker of the evening, Major George C. Danforth, chief engineer of the Maine Water Power Commission, who spoke on the Federal Water-Power Act.

The paper was discussed by Past President Swain, Past President Hale, Colonel Gunby and Mr. H. K. Barrows.

On conclusion of the discussion, on motion of Past President Swain it was voted:

"That the Society approve the formulation of resolutions providing for the amendment of the Federal Water-Power Act and that the draft of the resolutions be referred to a committee of five to be appointed by the President."

The President subsequently appointed the following as members of the committee: Mr. George C. Danforth, Mr. Richard A. Hale, Mr. Harold K. Barrows, Mr. William F. Uhl and Mr. James H. Manning.

Adjourned.

RICHARD K. HALE, *Acting Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[November 15, 1921.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Clark, Eldon Saunders, Boston, Mass. (Age 33, b. Boston, Mass.) Graduate of Mass. Inst. of Technology, civil engineering course, in 1910. Was assistant at M. I. T., 1910–11; with Barrows and Breed, 1911–14; with Power Construction Co., 1914; with Clark & Gow, 1915; with Stone & Webster, Inc., and Shipbuilding Corporation, 1916–21; with Metcalf & Eddy from March, 1921, to date, as assistant engineer along sewage disposal and water supply lines. Refers to L. S. Cowles, F. A. Marston, E. F. Rockwood, A. L. Shaw and J. P. Wentworth.

Heald, Harold Francis, Somerville, Mass. (Age 27, b. Boston, Mass.) Educated at Somerville High School, Y. M. C. A. Engineering School. From Jan., 1915, to Oct., same year, was with J. L. Woodfall; from Oct., 1915, to Feb., 1917, studied at Tufts College Engineering School; April, 1916, to Sept., 1916, in the engineering department, City of Medford; Feb. to June, 1917, attended Bates College; June, 1917, to Aug., 1919, was in the army, Co. C., 101st Engineers; Feb. to June, 1919, attended University de Caen, Normandy, France; Sept., 1919, to June, 1920, at Tufts College; June, 1920, to March, 1921, assistant engineer, Dept. of Public Works, Dominican Republic; March, 1921, to June, same year, Tufts College Engineering School; June, 1921, to date, engaged in his own building construction. Refers to R. Abbott, F. T. Flynn, R. F. Macauley, D. P. Steward, Jr., J. L. Woodfall and W. A. Woods.

Jackson, Karl Frederick, Newtonville, Mass. (Age 26, b. Springfield, Mass.) Graduated from Harvard University in 1917, having specialized in engineering sciences. From May, 1917, to May, 1919, served in the U. S. Army, Corps of Engineers, also with 101st U. S. Engineers, 26th Division. From June, 1919, to November, same year, with the Witherow Steel Co., Pittsburg, as concrete detailer; November, 1919, to June, 1920, with Lockwood, Greene & Co. as designing engineer of construction; from June, 1920, to the present time, with the Republic Fireproofing Co., Inc., as sales engineer and district manager. Refers to W. W. Bigelow, J. E. Hanlon, E. A. Norwood and J. F. Osborn.

LIST OF MEMBERS.

ADDITIONS.

Brennan, Fred S. ..... 70 Oxford St., Somerville, Mass.
Manning, James Henry ..... 147 Milk St., Boston, Mass.
Mulcare, Thomas ..... 1 Exeter St., Cambridge, Mass.
Váldes, Viviano L. ..... Hidalgo 121, Monterey, Mexico

CHANGES OF ADDRESS.

Bliss, Edwin P. ..... 170 Summer St., Malden, Mass.
Calderara, C. A. ..... Adams St., No. Abington, Mass.
Clapp, W. A. ..... 3415 West 60th St., Chicago, Ill.

Craib, Charles G. ..... 36 Waldemar Ave., Winthrop, Mass.
De Puy, Clarence S. ..... 2 Carnegie Ave., East Orange, N. J.
Durgin, Clyde M. ..... P. O. Box 3512, Boston, Mass.
Haggerty, Thomas J. ..... 765 Columbia Rd., Dorchester, Mass.
Hale, Richard A. ..... Essex Company, Lawrence, Mass.
Harsch, Erwin ..... 8 Chatham St., Cambridge, Mass.
Kennison, Karl R. ..... Room 606, 25 Pemberton Sq., Boston, Mass.
Klink, Nassime S. ..... P. O. Box 717, Mexia, Tex.
Longfellow, G. P. ..... Brunswick, Me.
Moulton, J. Wendell ..... 405 E. University St., Ann Arbor, Mich.
Mueser, William H.,
M. I. T. Dormitory, Charles River Rd., Cambridge, Mass.
Porter, Dwight ..... 149 Hawthorne St., Malden, Mass.
Sawtelle, Harry F. ..... 1768 Beacon St., Brookline, Mass.
Skillin, Fred B ..... Gen. Delivery, Rochester, N. Y.
Smith, Merritt, P. ..... Mass. Inst. Technology, Cambridge, Mass.
Sokoll, J. M.,
Care Aberthaw Construction Co., 27 School St., Boston, Mass.
Tucker, H. F. ..... 753 Boylston St. North, Seattle, Wash.
Warren, Henry E. ..... Leicester, Mass.

NOTE FROM THE FEDERATED AMERICAN ENGINEERING SOCIETIES.

At its meeting held in Washington, D. C., September 30, 1921, the Executive Board of American Engineering Council approved the Report of the Committee on Patents, which contained the following resolutions:

"*Whereas*, American Engineering Council, of The Federated American Engineering Societies, representing 43 000 engineers in member and affiliated societies, is strongly convinced of the importance of the Patent Office to the maintenance of the manufacturing and agricultural welfare and supremacy of the United States and is deeply concerned over the present precarious and inefficient condition of the Patent Office, the said American Engineering Council represents to Congress that, while the Patent Office was in a most serious condition in 1919, when the need of its relief was first brought to the attention of Congress, the work of the Patent Office has increased 67.6 per cent. since that time, while the Patent Office force has only been increased 5.4 per cent., the salaries of examiners remaining at but 10 per cent. more than they were in 1848, and the resignations of the Patent Office examiners have continued in increasing volume until but one half of the examining force now consists of properly trained examiners; and

"*Whereas*, the Lampert Patent Office Bill, H.R. 7077, provides the least increases in force and salaries which can possibly stop the retrogression of the Patent Office and enable it to make progress toward recovering an efficient condition, and by increases in the fees for patents, provides the funds necessary to enable the Patent Office to continue to be self-supporting;

"*Now, therefore*, AMERICAN ENGINEERING COUNCIL most urgently recommends to Congress the passage of said Lampert Patent Office Bill, H.R. 7077."

Your committee also recommends that a copy of the foregoing resolution be sent by you to each member of Congress and to each of the societies which is a member of The Federated American Engineering Societies or is affiliated therewith, with the request that it be published in the journal of such society, or otherwise called to the attention of its membership, and that each member of such society be requested to communicate with his Senators and personal Representatives, urging the immediate enactment of the Lampert Patent Office Bill.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Water Supply Paper 450.

Annual Report, Statistics of Express Companies. 1920.

State Reports.

Wisconsin. Wisconsin Survey. Bulletins 55 and 58.

Municipal Reports.

Boston, Mass. Annual Report Transit Department. 1920.

Lynn, Mass. Annual Report Commissioner Water Supply. 1920.

Medford, Mass. Annual Report Water and Sewer Commissioners. 1920.

New York, N. Y. Annual Report Bureau of Buildings. 1920.

St. Louis, Mo. Annual Report Water Commissioner. 1920.

Miscellaneous.

Education of Health Officers. George C. Whipple.
Method of Least Squares. Mansfield Merriman.
Transactions of American Inst. Min. & Met. Engrs. Vol. 64.
Tentative Standards American Society for Testing Materials. 1921.

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Vol. VIII DECEMBER, 1921 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Labor Problems of To-day." E. A. Johnson, James Gauld, William Stanley Parker, Morton C. Tuttle and Chas. R. Gow.

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MINUTES OF MEETING.

BOSTON, November 16, 1921.

The regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.00 o'clock by the first Vice-President, Frank M. Gunby.

There were 154 members and guests present.

The minutes of the meeting of October 19 were read and approved.

The chairman announced that the Board of Government had elected the following to membership in the grades named:

Member — Mr. Richard S. Holmgren.

Juniors — Messrs. Karle H. Aimo, Earle C. Allen, Henry Brask, Harold S. Cook, Charles S. Cooper, John J. Cummings, Joseph V. Cundari, Allen S. Dawe, Elmore L. Dearborn, Herbert C. Dixon, Joseph B. Fitzpatrick, George E. Foisie, Joseph P. Furrier, Alfred Gargaro, Maurice Grushky, Harold W. Hale,

Arthur E. Harding, David J. Kenney, Guy S. Longstroth, Elmer F. Low, John P. McManus, David C. Milne, Howard T. Pearce, Carl R. Pearson, Irving Rosenblatt, Alan M. Thompson, Harold C. Thompson, Arthur L. Wilcox, Lawrence V. Willey and Edwin C. Williams.

The Vice-President presented a memoir of Roy C. Aiken, prepared by Mr. John L. Howard. Mr. Aiken died on June 24, 1921.

On motion of Mr. Frederic I. Winslow, the following vote, passed at the last meeting, was passed a second time, as required by the By-Laws, by a unanimous vote:

"Voted: That the Board of Government be authorized to use the income from the Permanent Fund to meet current expenses to such an extent as they deem necessary."

The chairman then introduced the speakers of the evening. Mr. E. A. Johnson, secretary of the Building Trades Council; Mr. James Gauld, Carpenters' District Council; Mr. William Stanley Parker, architect; Mr. Morton C. Tuttle, of the Aberthaw Construction Company, and Mr. Charles R. Gow, of the Charles R. Gow Company, who talked on "Labor Problems of To-day." The papers were followed by a discussion in which the speakers and Messrs. Metcalf, Larned, Sampson, Snow and Spofford took part.

Adjourned.

RICHARD K. HALE, *Acting Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[December 15, 1921.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communi-

cate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Burke, George L., Norwood, Mass. (Age 21, b. Norwood, Mass.) Student at Northeastern College. April to Nov., 1917, was draftsman with Geo. H. Morrill Co.; Nov., 1917, to Nov., 1918, transitman with the town of Norwood; Nov., 1918, to April, 1919, with the U. S. Army; April, 1919, to Sept., 1920, transitman with town of Norwood: from Sept., 1920, to date, at college. Refers to H. B. Alvord, C. S. Ell, C. R. Gow, A. L. Maddox and G. A. Smith.

Dary, Erol Gay, Hyde Park, Mass. (Age 26, b. Taunton, Mass.) Educated in public schools, Bryant & Stratton Commercial School, Rhode Island School of Design, Franklin Union and Lowell Institute; 1913, Hood Rubber Co., power plant drafting; 1914, United Illuminating Co., New Haven, steam power plant layouts and inspection of construction; 1915, machine detailing and design at Norfolk Downs; 1916, with Stone & Webster, structural steel and concrete drafting; 1917, B. & M. R. R., steel, concrete and timber bridge drafting: 1918, with Stone & Webster again, also was in chemical warfare service, U. S. Army; 1919, at Watertown Arsenal, building design and construction; 1920, with C. B. Roberts Engrg. Co., in charge of structural design and drafting on the plant of the N. E. Oil Refining Co., at Fall River, Mass.; 1921, with Leonard Engrg. Co., on large concrete oil storage tanks at the Beacon Oil Co., Everett, Mass. Refers to W. W. Clifford, C. M. Durgin, H. A. Gray, P. Jones and E. D. Mortenson.

Flood, Frank Lee, Framingham, Mass. (Age 24, b. Framingham, Mass.) Graduate of Framingham High School in 1915, and now a student at Northeastern College, department of civil engineering. Transitman with William H. Punchard, landscape architect, 1916–17; in the U. S. Army from April, 1917, to May, 1919; transitman and assistant engineer with Commission of Water Supply Resources since Oct., 1920. Now attending fourth year at the Northeastern College, and doing coöperative work as assistant engineer with the Commission on Water Supply Resources. Refers to H. B. Alvord, C. S. Ell, N. L. Hammond, A. S. Weston and E. Wright.

Murdough, Edwin Bennett, Dorchester, Mass. (Age 23, b. Dorchester, Mass.) Graduated from Mass. Inst. of Tech. in 1920. Employed by the M .P. R. R. at Atchison, Kan., as rodman from July to Nov., 1920; at present

with Metcalf & Eddy, as assistant engineer. Refers to F. S. Bailey, C. E. Carter, C. B. Breed, C. W. Rolfe, A. L. Shaw and C. M. Spofford.

Nightingale, Winthrop E., Watertown, Mass. (Age 27, b. Rockland, Mass.) Graduate of Boston Latin School in 1911, and Harvard College, A.B., in 1915. Sept., 1915, to Feb., 1916, instrumentman for P. C. Nash, then of Watertown; deck officer U. S. Coast and Goedetic Survey, March to June, 1916; resident inspector, Mass. Highway Commission, to Jan., 1917; draftsman, Kalmus, Comstock & Westcott, to Feb., 1917; Mass. Inst. of Tech., Feb., 1917, to June, 1918; Boston Park and Recreation Dept., Engineering Division, July, 1917, to June, 1918; U. S. N. R. F., June, 1918, to Feb., 1919; with Lockwood, Greene & Co., Oct., 1919, to July, 1920; Mass. Highway, Division of Public Works, Oct., 1920, to March, 1921; director of engineering practice at Northeastern College, March, 1921, to date. Refers to A. B. Appleton, C. S. Ell, H. J. Hughes, L. J. Johnson, C. M. Spofford, P. W. Taylor.

Nyman, Chester Lovering, Marlboro, Mass. (Age 20, b. Marlboro, Mass.) Studied at Northeastern College, civil engineering course, 1918. Worked half of 1919 with H. W. Punchard, landscape architect; with the State Department of Health, 1920, as transitman and chief of party; during summer and fall of 1921 was with the State Highway Commission at Beverly,— this included inspection and engineering on concrete, gravel and bituminous road construction. At present is a transitman with the Highway Commission in connection with studies at Northeastern College. Refers to H. B. Alvord, C. S. Ell, N. L. Hammond, A. P. Rice, A. D. Weston, E. Wright.

Oakman, Roger Gordon, Neponset, Mass. (Age 20, b. Boston, Mass.) A graduate of Mechanic Arts High School, Boston, 1920; entered Northeastern College, School of Engineering, in Sept., 1920, — is now a sophomore. Since July, 1920, has worked with C. H. Gannett, alternating five weeks working and five weeks at college. Refers to H. B. Alvord, C. S. Ell, C. H. Gannett and J. E. Stone.

Parsons, Alfred Dyer, Melrose, Mass. (Age 22, b. West Medford, Mass.) Graduate of Melrose High School in 1916, then took a post-graduate course and entered Mass. Inst. of Tech., in 1917, attending for about three years, and then entered Northeastern College. Has worked at different engineering jobs and kept up his civil engineering course at Northeastern. This is his senior year. Is now with the State Highway during the work periods. Refers to H. B. Alvord, J. B. Babcock, 3d, C. S. Ell, A. G. Robbins.

Riggio, Samuel Adams, Boston, Mass. (Age 20, b. Ivoryton, Conn.) Graduate of Pratt High School, Essex, Conn., June, 1920. Entered Northeastern College in Sept., 1920, and is now a sophomore. Refers to H. B. Alvord, C. S. Ell, C. R. Gow and N. L. Hammond.

Stotz, Herman Christian, Brighton, Mass. (Age 18, b. Boston, Mass.) Graduate of Mechanic Arts High School, 1920; entered Northeastern College in Sept. of 1920 and is now a sophomore. During the work periods of five weeks each has been employed by the Commission of Water Supply for the State of Massachusetts. Refers to H. B. Alvord, C. S. Ell, C. R. Gow and N. L. Hammond.

LIST OF MEMBERS.

CHANGES OF ADDRESS.

CRANDALL, JAMES S. . . . . 25 East St., Melrose, Mass.
FEAR, HOLBERT W. . . . . 31 Chestnut St., Gloversville, N. Y.
LINCOLN, EDWIN H. . . . . 46 Cornhill, Boston, Mass.
NEGUS, ARTHUR I. . . . . Damariscotta Mills, Me.
PEABODY, DEAN, Jr. . . . . Room 1-302, M. I. T., Cambridge, Mass.
WHITMORE, HAROLD C. . Box 546, care Stone & Webster, Inc., Troy, N. Y.
WORCESTER, ROBERT J. H., care Lockwood, Greene & Co., 60 Federal St., Boston 9, Mass.

ADDITIONS.

CURRIER, GEORGE W. . . . . 602 City Hall Annex, Boston, Mass.
FOISIE, GEORGE E., Northeastern College, 316 Huntington Ave., Boston, Mass.
HOLMGREN, RICHARD S. . . . . 32 Pleasant View Ave., E. Lynn, Mass.
KENT, ROBERT W. . . . . 29 Morseland Ave., Newton Center, Mass.

DEATH.

BAKER, WILLIAM E. . . . . November 7, 1921

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Annual Report, Governor of Panama Canal. 1921.

State Reports.

Massachusetts. Annual Report of Highway Commission. 1917 and 1918.

New York. Annual Report State Dept. of Health. Vols. 1 and 2.

New York. Annual Report Public Service Commission. 1917.

Municipal Reports.

Boston, Mass. Annual Report City Planning Board. 1920.

Marlborough, Mass. Annual Report Water and Sewage Commissioners. 1920.

Philadelphia, Pa. Annual Report City Transit. 1920.

Miscellaneous.

Bulletin 564. Dept. of Mines, Canada.

Index to Transactions, American Society Civil Engrs. Vols. 1–83.

Transactions, American Society Civil Engrs. Vol. 84.

Waste in Industry. F. A. E. S. 1921.

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